JT4020 Mach 1/All Terrain

Operator's Manual

CE

CMW®

Issue 2.0

053-1088

Overview

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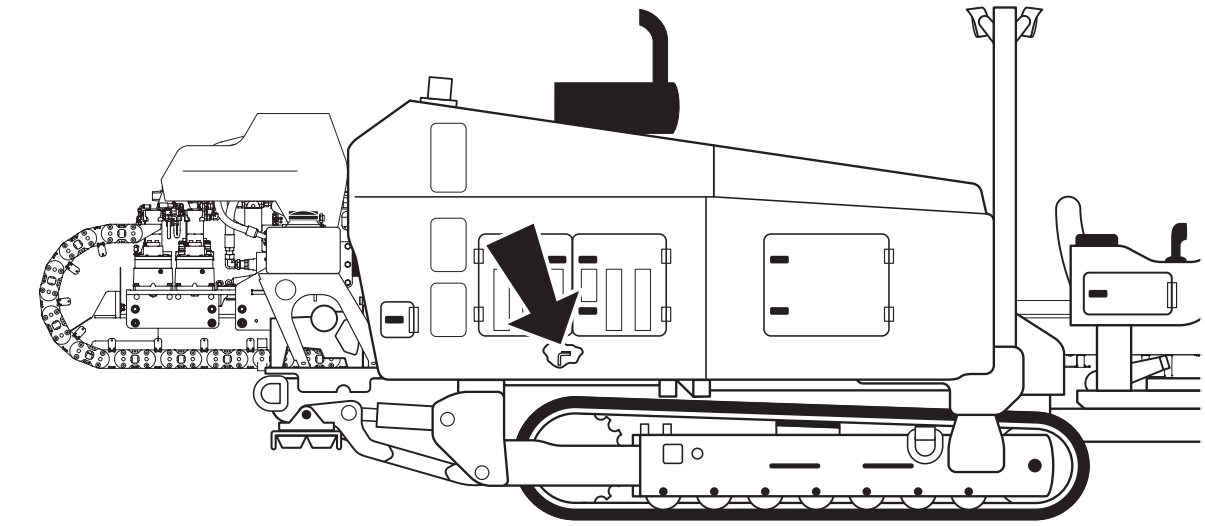
Serial Number Location

Record serial numbers and date of purchase in spaces provided. Drilling unit serial number is located as shown.



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Item	
Date of manufacture	
Date of purchase	
Drilling unit serial number	
Engine serial number	
Trailer serial number	

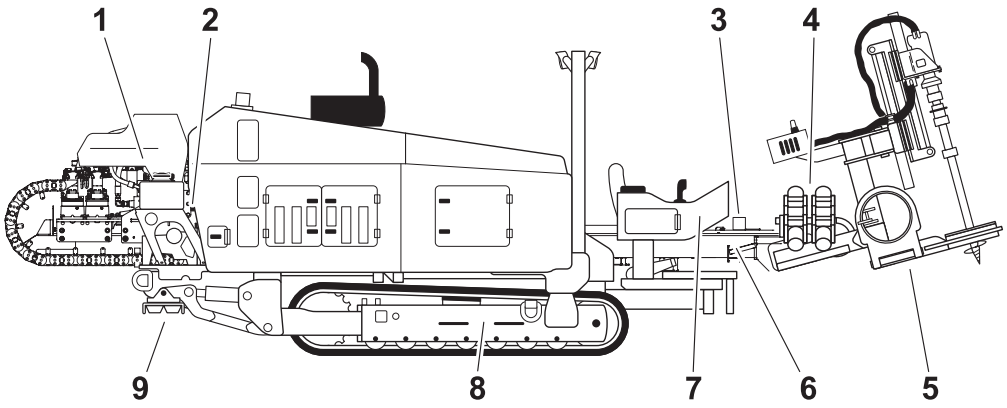
Intended Use

The JT4020 Mach 1/All Terrain is a self-contained horizontal directional drilling unit capable of drilling through solid rock, cobblestone, broken rock, gravel, and other soil/rock mixes, as well as less extreme soil conditions. It is designed to install buried cable and pipe at distances to 1,000' (300 m) depending on soil conditions.

The unit is designed for operation in temperatures typically experienced in earth moving and construction work environments. Provisions may be required to operate in extreme temperatures. Contact your Ditch Witch dealer. Use in any other way is considered contrary to the intended use.

The unit can be used with Ditch Witch drilling fluid units and Ditch Witch locating equipment. It should be operated, serviced, and repaired only by persons familiar with its particular characteristics and acquainted with the relevant safety procedures.

Unit Components



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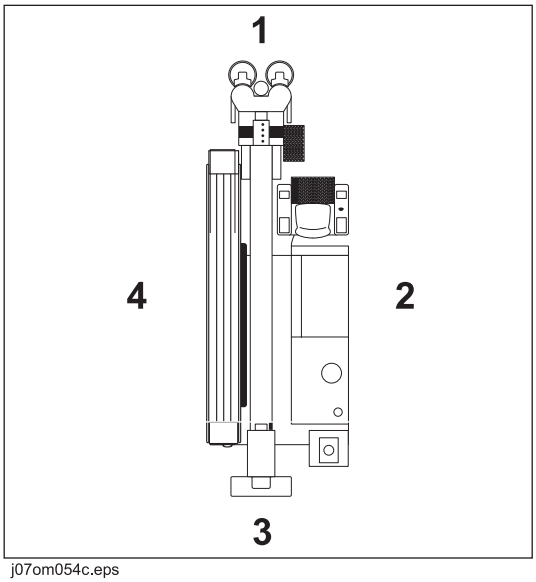
1. Carriage
2. Spindle
3. Pipeloader
4. Vise wrenches
5. Anchoring system
6. Drill frame
7. Operator's station
8. Tracks
9. Stabilizer

Operator Orientation

1. Front of unit
2. Right side of unit
3. Rear of unit
4. Left side of unit



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About This Manual

This manual contains information for the proper use of this machine. See the beige **Operation Overview** pages for basic operating procedures. Cross references such as "See page 50" will direct you to detailed procedures.

Bulleted Lists

Bulleted lists provide helpful or important information or contain procedures that do not have to be performed in a specific order.

Numbered Lists

Numbered lists contain illustration callouts or list steps that must be performed in order.

Foreword

This manual is an important part of your equipment. It provides safety information and operation instructions to help you use and maintain your Ditch Witch equipment.

Read this manual before using your equipment. Keep it with the equipment at all times for future reference. If you sell your equipment, be sure to give this manual to the new owner.

If you need a replacement copy, contact your Ditch Witch dealer. If you need assistance in locating a dealer, visit our website at **www.ditchwitch.com** or write to the following address:

The Charles Machine Works, Inc.
Attn: Marketing Department
PO Box 66
Perry, OK 73077-0066
USA

The descriptions and specifications in this manual are subject to change without notice. The Charles Machine Works, Inc. reserves the right to improve equipment. Some product improvements may have taken place after this manual was published. For the latest information on Ditch Witch equipment, see your Ditch Witch dealer.

Thank you for buying and using Ditch Witch equipment.

JT4020 Mach 1/All Terrain (Tier 3) Operator's Manual

Issue number 2.0/OM-12/07
Part number 053-1088

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This product is covered by one or more of the following patents:
U.S. B1 4,858,704; 4,953,638; 5,148,880; 5,242,026; 5,341,887; 5,490,569; 5,544,712; 5,546,833; 5,682,956; 5,684,466; 5,713,423; 5,794,719; 5,880,680; 5,941,322; 6,085,852; 6,109,371; 6,179,065; 6,216,803; 6,250,403; 6,250,404; 6,290,606; 6,311,790; 6,411,094; 6,543,551; 6,550,547; RE37,450; RE37,923; RE37,975; **Germany** 694 17 019; 695 29 634; **France** 683,845; 674,093; **Australia** 684,595; 689,533; 718,034; 706,544; 755,862; **UK** 2,309,239; 2,312,006; EP683,845; EP674,093 ; other U.S. and foreign patents pending.

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machine serial number, information about the type of work this machine is designed to perform, basic machine components, and how to use this manual

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part number, revision level, and publication date of this manual, and factory contact information

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machine safety alerts and emergency procedures

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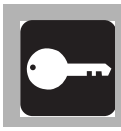
machine controls, gauges, and indicators and how to use them



Operation Overview 59
an overview for completing a job with this machine: planning, setting up, installing product, and restoring the jobsite; with cross references to detailed procedures

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procedures for inspecting and classifying the jobsite, planning the installation path, and preparing the jobsite for work

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machine specifications including weights, measurements, power ratings, and fluid capacities

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a record of major service performed on the machine

Safety

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Guidelines

Follow these guidelines before operating any jobsite equipment:

- Complete proper training and read operator's manual before using equipment.
- Contact your local One-Call (811 in USA) or the One-Call referral number (888-258-0808 in USA and Canada) to have underground utilities located before digging. Also contact any utilities that do not participate in the One-Call service.
- Classify jobsite based on its hazards and use correct tools and machinery, safety equipment, and work methods for jobsite.
- Mark jobsite clearly and keep spectators away.
- Wear personal protective equipment.
- Review jobsite hazards, safety and emergency procedures, and individual responsibilities with all personnel before work begins. Safety videos are available from your Ditch Witch dealer.
- Replace missing or damaged safety shields and safety signs.
- Use equipment carefully. Stop operation and investigate anything that does not look or feel right.
- Do not operate unit where flammable gas is present.
- Contact your Ditch Witch dealer if you have any question about operation, maintenance, or equipment use.

Safety Alert Classifications

These classifications and the icons defined on the following pages work together to alert you to situations which could be harmful to you, jobsite bystanders or your equipment. When you see these words and icons in the book or on the machine, carefully read and follow all instructions. YOUR SAFETY IS AT STAKE.

Watch for the three safety alert levels: **DANGER**, **WARNING** and **CAUTION**. Learn what each level means.

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Watch for two other words: **NOTICE** and **IMPORTANT**.

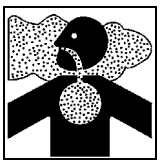
NOTICE can keep you from doing something that might damage the machine or someone's property. It can also alert you against unsafe practices.

IMPORTANT can help you do a better job or make your job easier in some way.

Safety Alerts

DANGER Turning shaft will kill you or crush arm or leg. Stay away.

DANGER Electric shock. Contacting electric lines will cause death or serious injury. Know location of lines and stay away.



DANGER Deadly gases. Lack of oxygen or presence of gas will cause sickness or death. Provide ventilation.

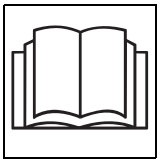
DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

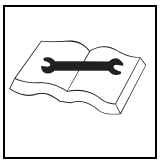
WARNING Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away.

WARNING Moving parts could cut off hand or foot. Stay away.

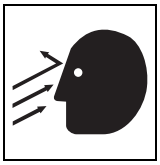
WARNING Explosion possible. Serious injury or equipment damage could occur. Follow directions carefully.



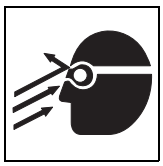
WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.



WARNING Improper control function could cause death or serious injury. If control does not work as described in instructions, stop machine and have it serviced.



WARNING Looking into fiber optic cable could result in permanent vision damage. Do not look into ends of fiber optic or unidentified cable.



WARNING Pressurized fluid or air could pierce skin and cause injury or death. Stay away.

WARNING Fire or explosion possible. Fumes could ignite and cause burns. No smoking, no flame, no spark.

WARNING Moving traffic - hazardous situation. Death or serious injury could result. Avoid moving vehicles, wear high visibility clothing, post appropriate warning signs.

WARNING Hot pressurized cooling system fluid could cause serious burns. Allow to cool before servicing.

CAUTION Flying objects may cause injury. Wear hard hat and safety glasses.

CAUTION Hot parts may cause burns. Do not touch until cool.

CAUTION Exposure to high noise levels may cause hearing loss. Wear hearing protection.

CAUTION Fall possible. Slips or trips may result in injury. Keep area clean.

CAUTION Battery acid may cause burns. Avoid contact.

CAUTION Improper handling or use of chemicals may result in illness, injury, or equipment damage. Follow instructions on labels and in material safety data sheets (MSDS).

Emergency Procedures

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

Before operating any equipment, review emergency procedures and check that all safety precautions have been taken.

EMERGENCY SHUTDOWN - Turn ignition switch to stop position or push remote engine stop button (if equipped).

Electric Strike Description

DANGER Electric shock. Contacting electric lines will cause death or serious injury. Know location of lines and stay away.

When working near electric cables, remember the following:

- Electricity follows all paths to ground, not just path of least resistance.
- Pipes, hoses, and cables will conduct electricity back to all equipment.
- Low voltage current can injure or kill. Almost one-third of work-related electrocutions result from contact with less than 440 volts.

Most electric strikes are not noticeable, but indications of a strike include:

- power outage
- smoke
- explosion
- popping noises
- arcing electricity

If any of these occur, or if strike alarm sounds or flashes, assume an electric strike has occurred.

If an Electric Line is Damaged

If you suspect an electric line has been damaged and you are **on drilling unit or bonded ground mats**, DO NOT MOVE. Remain on drilling machine or mats and take the following actions. The order and degree of action will depend on the situation.

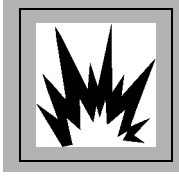
- Warn people nearby that an electric strike has occurred.
- Have someone contact electric company.
- Reverse drilling direction and try to break contact. Do not touch drill pipe with hands or hand-held tools.
- Press electric strike system status button.
    - If alarm sounds again, stay where you are and wait for electric company to shut off power.
    - If alarm does not sound and there is no other indication of a strike, wait at least one full minute before moving away from equipment. Utility might use automatic reclosers which will restart current flow. If alarm sounds again while waiting, stay where you are until electric company shuts off power.
    - If alarm does not sound but all lights in strike indicator are on, assume strike is continuing and stay where you are until electric company shuts off power.
- Do not resume drilling or allow anyone into area until given permission by electric company.

If you suspect an electric line has been damaged and you are **off drilling unit or bonded ground mats**, DO NOT TOUCH ANY EQUIPMENT connected to drilling unit. Take the following actions. The order and degree of action will depend on the situation.

- Stay where you are unless you are wearing electric insulating boots. If you leave, do not return to area or allow anyone into area until given permission by electric company.

If a Gas Line is Damaged

WARNING Fire or explosion possible. Fumes could ignite and cause burns. No smoking, no flame, no spark.



WARNING Explosion possible. Serious injury or equipment damage could occur. Follow directions carefully.

If you suspect a gas line has been damaged, take the following actions. The order and degree of action will depend on the situation.

- Immediately shut off engine(s), if this can be done safely and quickly.
- Remove any ignition source(s), if this can be done safely and quickly.
- Warn others that a gas line has been cut and that they should leave the area.
- Leave jobsite as quickly as possible.
- Immediately call your local emergency phone number and utility company.
- If jobsite is along street, stop traffic from driving near jobsite.
- Do not return to jobsite until given permission by emergency personnel and utility company.

If a Fiber Optic Cable is Damaged

Do not look into cut ends of fiber optic or unidentified cable. Vision damage can occur.

If Machine Catches on Fire

Perform emergency shutdown procedure and then take the following actions. The order and degree of action will depend on the situation.

- Immediately move battery disconnect switch (if equipped) to disconnect position.
- If fire is small and fire extinguisher is available, attempt to extinguish fire.
- If fire cannot be extinguished, leave area as quickly as possible and contact emergency personnel.

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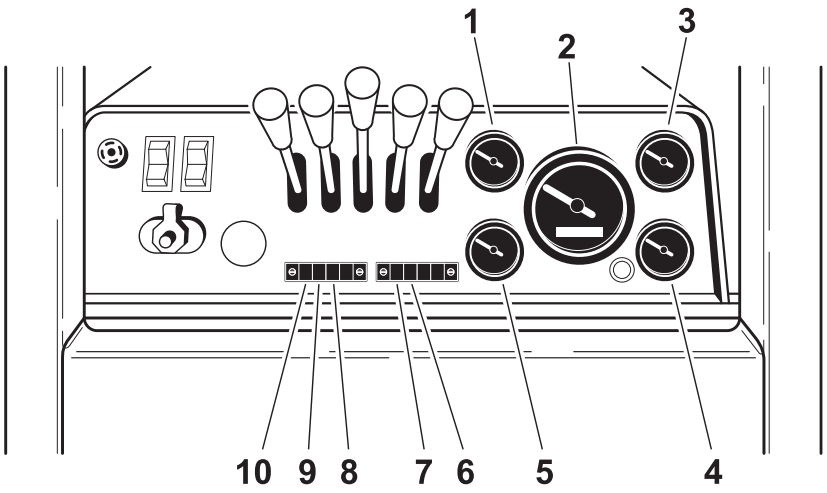
Set-Up Console

Gauges and Indicators



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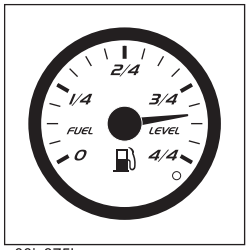
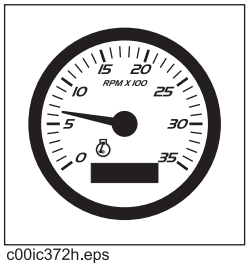
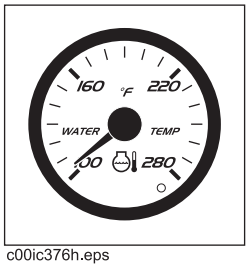
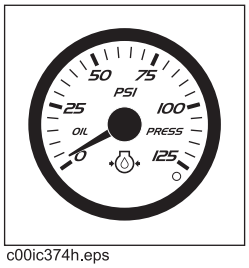
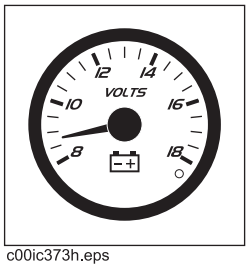
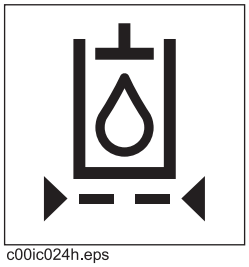
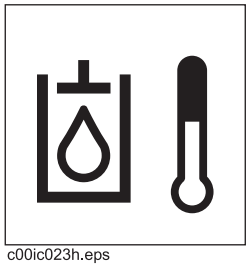
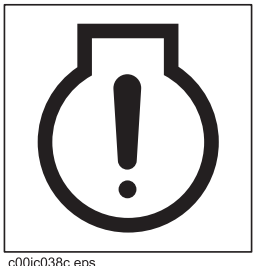
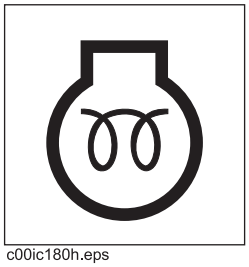
1. Fuel gauge
2. Tachometer with diagnostic display
3. Engine coolant temperature gauge
4. Engine oil pressure gauge
5. Voltmeter
6. Hydraulic fluid filter service indicator
7. Hydraulic fluid temperature indicator
8. Engine shutdown indicator
9. Operator alert indicator
10. Engine preheat indicator

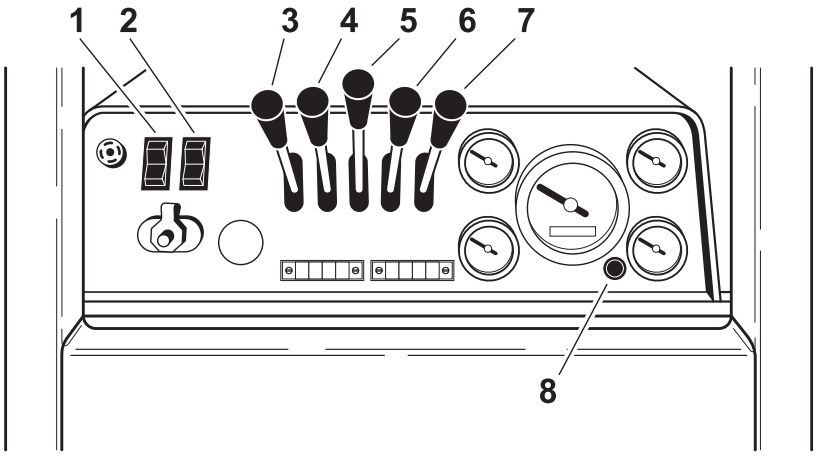
Item	Description	Notes
1. Fuel gauge  c00ic375h.eps	Displays fuel level in tank.	Use only #2 diesel fuel. In temperatures below 40° F (4° C), use #1 diesel fuel. Tank holds 55 gal (208 L).

Item	Description	Notes
2. Tachometer & diagnostic gauge  c00ic372h.eps	Tachometer Displays engine RPM. **Diagnostic gauge** Displays engine hours, trip meter, engine statistics, and engine diagnostic codes. To view information, press the selection switch.	**IMPORTANT:** For more information about the engine diagnostic system and codes see "Engine Diagnostic Codes" on page 157. **IMPORTANT:** For more information about the selection switch, see "Selection switch" on page 26.
3. Engine coolant temperature gauge  c00ic376h.eps	Displays engine coolant temperature.	Normal coolant temperature is 190°-220° F (88°-105° C). **IMPORTANT:** Do not operate machine when coolant temperature exceeds 240° F (116° C). If engine become too hot, engine will shut down. See "Engine shutdown indicator" on page 22.
4. Engine oil pressure gauge  c00ic374h.eps	Displays engine oil pressure.	Full load reading should be 35-65 psi (2.4-4.5 bar). At idle, reading should not drop below 15 psi (1 bar). If there is no oil pressure for 5 seconds, engine will shut down. See "Engine shutdown indicator" on page 22.
5. Voltmeter  c00ic373h.eps	Displays system voltage.	Should show 13-14V with engine running.

Item	Description	Notes
6. Hydraulic fluid filter service indicator  c00ic024h.eps	Lights when hydraulic fluid filter needs replacing.	Change filter when indicator lights continuously and engine is warm.
7. Hydraulic fluid temperature indicator  c00ic023h.eps	Lights when hydraulic fluid is overheating.	Check hydraulic fluid level.
8. Engine shutdown indicator c00ic314h.eps	Lights when an critical engine fault occurs. Engine will shut down 30 seconds after light comes on.	A code will be stored in the ECU. See "Diagnostic gauge" on page 21 for more information. **IMPORTANT:** See "Tier 3 Engine" on page 157 for more information on diagnostic system and diagnostic codes. To reset, turn ignition switch to STOP, then to run.
9. Operator alert indicator  c00ic038c.eps	Lights when a non-critical engine fault occurs.	A code will be stored in the ECU. See "Diagnostic gauge" on page 21 for more information. **IMPORTANT:** See "Tier 3 Engine" on page 157 for more information on diagnostic system and diagnostic codes.

Item	Description	Notes
10. Engine preheat indicator  c00ic180h.eps	Lights when air intake pre-heater is operating.	**NOTICE:** If indicator is on, wait until it goes out before starting engine. **IMPORTANT:** If ignition switch is turned to start position before indicator goes out, the system will be disabled and must be reset. To reset, turn ignition switch to STOP, then to run.

Controls



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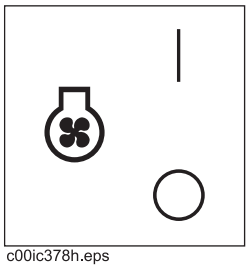
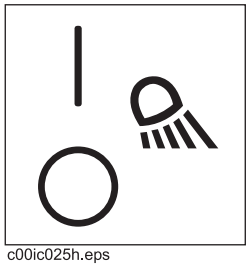
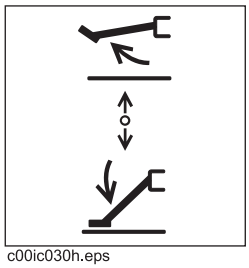
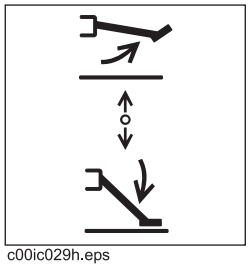
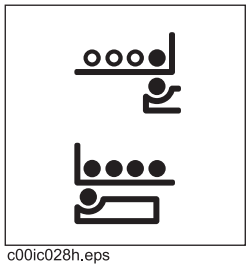
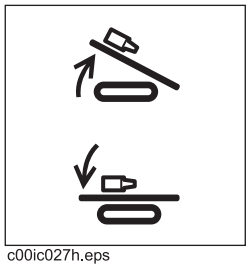
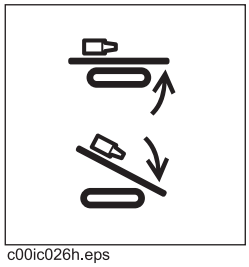
1. Hi/auto fan speed switch
2. Work light switch
3. Right stabilizer control
4. Left stabilizer control
5. Shuttle stop control
6. Back frame tilt control
7. Front frame tilt control
8. Selection Switch

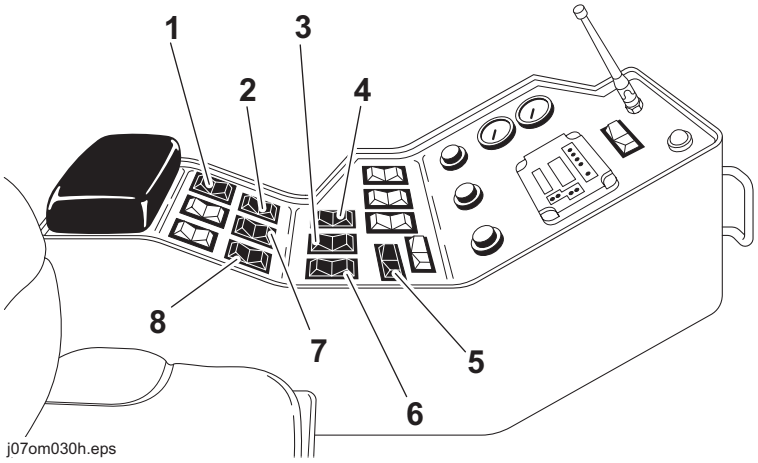
Item	Description	Notes
1. High/auto fan speed switch  c00ic378h.eps	For high speed, press top. For automatic speed, press bottom.	**IMPORTANT:** If switch is on **high speed** , fan will run at full rpm all the time. If switch is on **auto speed**, fan will speed will vary.

Item	Description	Notes
2. Light switch  c00ic025h.eps	To turn on, press top. To turn off, press bottom.	
3. Right stabilizer control  c00ic030h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** Lower right and left stabilizers to the ground together, then adjust individually.
4. Left stabilizer control  c00ic029h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** Lower left and right stabilizers to the ground together, then adjust individually.
5. Shuttle stop control  c00ic028h.eps	To lower shuttle stop, push up. To raise shuttle stop, pull down.	**IMPORTANT:** Look at pipe row indicator on drill frame to see which row shuttles will stop under.
6. Back frame tilt control  c00ic027h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** To ensure a stable platform for drilling, use front and back tilt controls together to set frame at desired pitch without raising tracks off the ground.

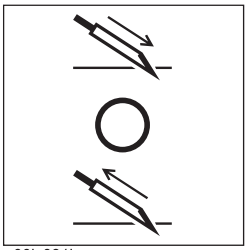
Item	Description	Notes
7. Front frame tilt control  c00ic026h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** To ensure a stable platform for drilling, use front and back tilt controls together to set frame at desired pitch without raising tracks off the ground.
8. Selection switch	To scroll through engine statics and diagnostic codes on diagnostic gauge display, push.	

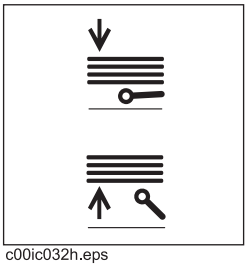
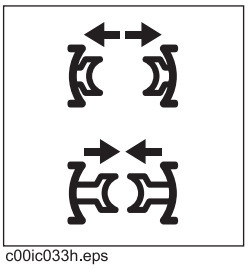
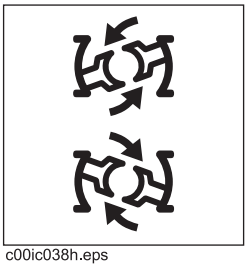
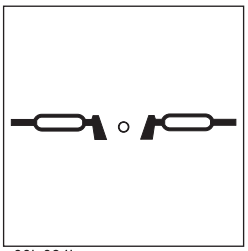
Left Control Console

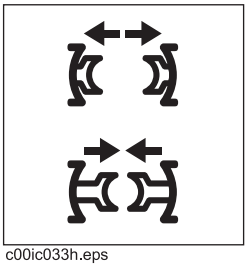
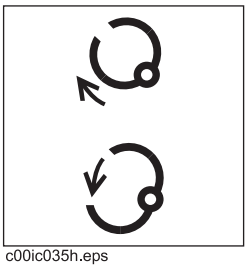
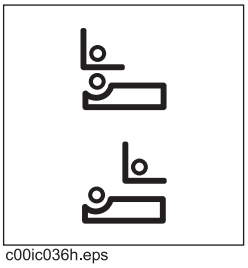
Pipeloading Controls



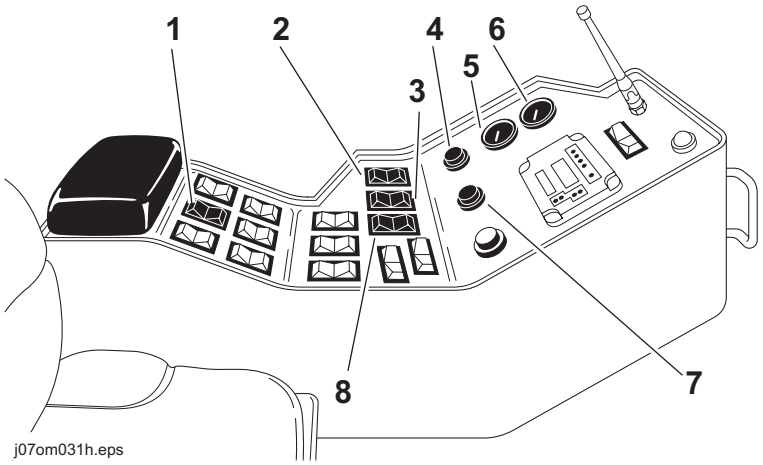
1. Add pipe/manual/remove pipe switch
2. Pipe lift switch
3. Rear wrench clamp switch
4. Rear wrench rotation switch
5. Pipe lubricator switch
6. Front wrench clamp switch
7. Pipe gripper switch
8. Pipe shuttle switch

Item	Description	Notes
1. Add pipe/manual/ remove pipe switch  c00ic031h.eps	To select "add pipe" automated pipeloader function, press top. To use manual pipeloader controls, move to center. To select "remove pipe" automated pipeloader function, press bottom.	See "Add Pipe" on page 102. See "Remove Pipe" on page 109.

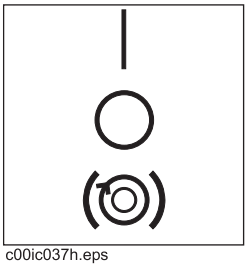
Item	Description	Notes
2. Pipe lift switch  c00ic032h.eps	To lower, press top. To raise, press bottom.	
3. Rear wrench clamp switch  c00ic033h.eps	To unclamp, press top. To clamp, press bottom.	
4. Rear wrench rotation switch  c00ic038h.eps	To rotate counterclockwise, press top. To rotate clockwise, press bottom. To stop rotation, release.	
5. Pipe lubricator switch  c00ic034h.eps	To fill applicator at back of pipeloader, press left. To apply joint compound to threads at wrenches, press right.	

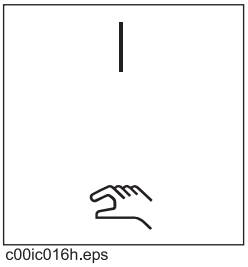
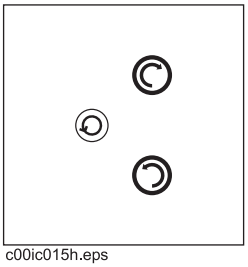
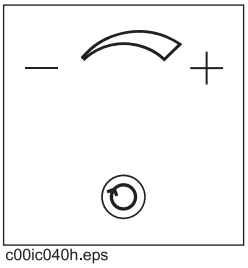
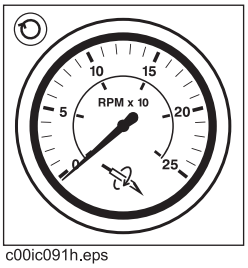
Item	Description	Notes
6. Front wrench clamp switch  c00ic033h.eps	To unclamp, press top. To clamp, press bottom.	
7. Pipe gripper switch  c00ic035h.eps	To close, press top. To open, press bottom.	
8. Pipe shuttle switch  c00ic036h.eps	To move toward pipe box, press top. To move toward spindle, press bottom.	

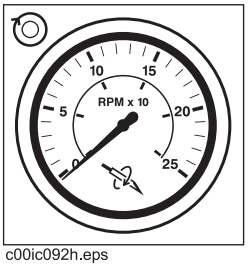
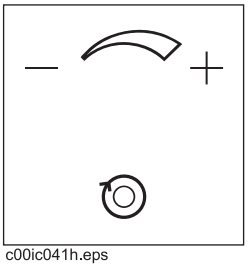
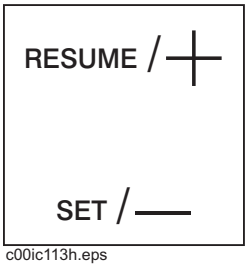
Drilling Controls



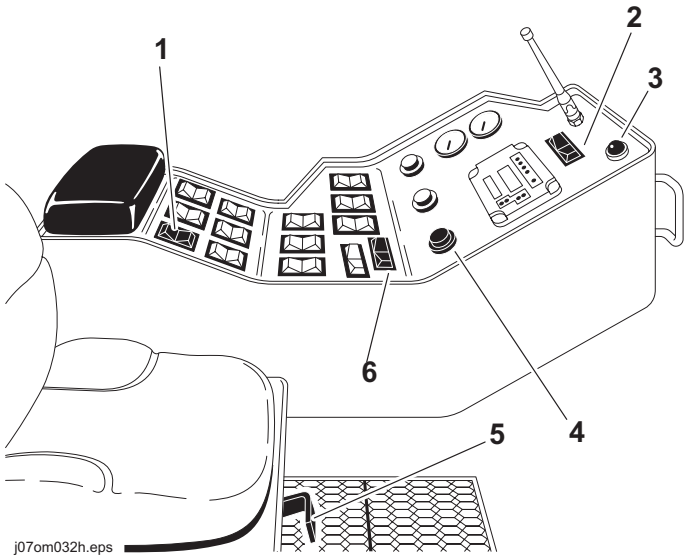
1. Spindle brake switch
2. Inner spindle switch
3. Manual inner rotation switch
4. Inner rotation speed control
5. Inner spindle tachometer
6. Outer spindle tachometer
7. Outer rotation speed control
8. Set/resume switch

Item	Description	Notes
1. Spindle brake switch  c00ic037h.eps	To engage, press top. To disengage, press bottom.	**IMPORTANT:** Use when making directional change.

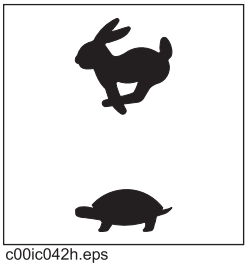
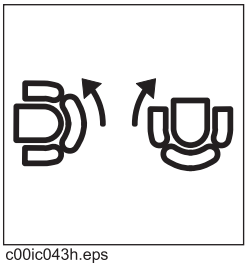
Item	Description	Notes
2. Inner spindle switch  c00ic016h.eps	To turn on, press top. To turn off, move to center. To manually dither, press and hold bottom and toggle manual inner rotation switch.	**IMPORTANT:** To restart inner rotation after operator has left seat, turn inner rotation off and then on.
3. Manual inner rotation switch  c00ic015h.eps	To rotate clockwise, press top. To rotate counterclockwise, press bottom. To stop rotation, release switch.	**IMPORTANT:** Inner spindle switch must be held down.
4. Inner rotation speed control  c00ic040h.eps	To increase inner rotation speed, turn clockwise. To decrease inner rotation speed, turn counterclockwise.	
5. Inner spindle tachometer  c00ic091h.eps	Displays inner spindle speed.	

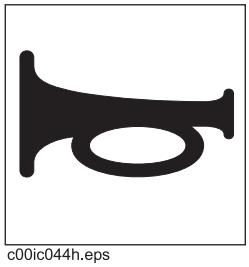
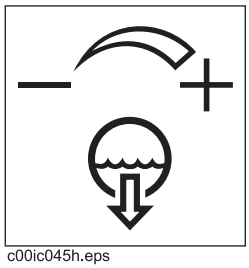
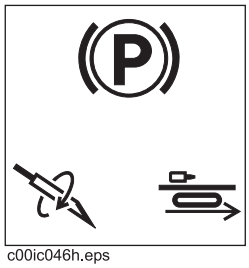
Item	Description	Notes
6. Outer spindle tachometer  c00ic092h.eps	Displays outer spindle speed.	
7. Outer rotation speed control  c00ic041h.eps	To increase outer rotation maximum speed above 140 rpm, turn clockwise. To decrease outer rotation maximum speed toward 140 rpm, turn counterclockwise.	**IMPORTANT:** Unless outer rotation speeds greater than 141 rpm are needed, keep knob turned fully counterclockwise to maintain full torque.
8. Set/Resume switch  c00ic113h.eps	To resume operation or increase operation levels, press top. To set operating conditions or reduce operation levels, press bottom.	See "Cruise Control" on page 151.

Operation Controls



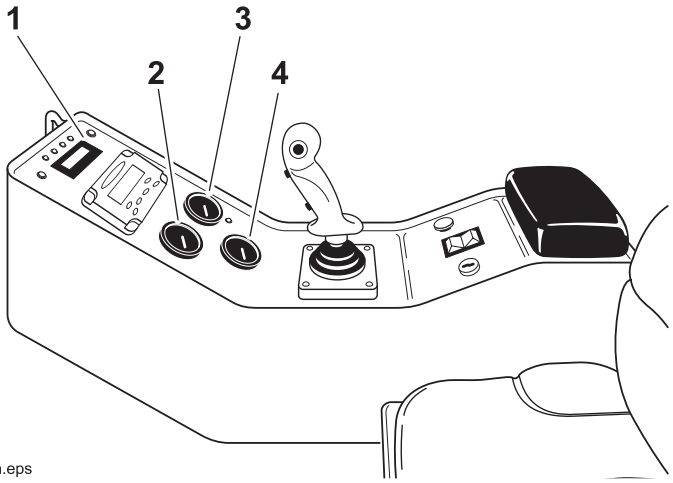
1. Engine throttle switch
2. Operator's station pivot control switch
3. Horn
4. Fluid flow control
5. Operator's station pivot lock
6. Drill/Park/Drive switch

Item	Description	Notes
1. Engine throttle switch  c00ic042h.eps	To increase speed, press top. To decrease speed, press bottom. To further increase or decrease speed, press additional times.	
2. Operator's station pivot control switch  c00ic043h.eps	To pivot into drilling position, lift pivot lock and press left. To pivot into driving position, press right.	

Item	Description	Notes
3. Horn  c00ic044h.eps	To sound horn, press.	
4. Fluid flow control  c00ic045h.eps	To increase flow, turn clockwise. To decrease flow, turn counterclockwise.	
5. Operator's station pivot lock	To unlock, lift and hold while pivoting operator's station into drilling position. Control will lock when operator's station reaches driving position.	
6. Drill/Park/Drive switch  c00ic046h.eps	To drill, press left. Drill icon will light. To set parking brake, move to center. Parking brake icon will light. To drive, press right. Drive icon will light.	**IMPORTANT:** Lighted icon on switch indicates unit is ready to perform that function.

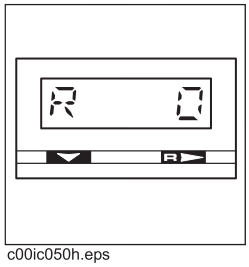
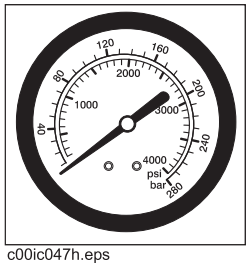
Right Control Console

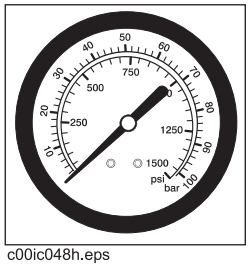
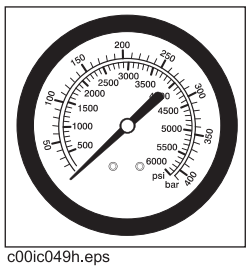
Gauges and Indicators



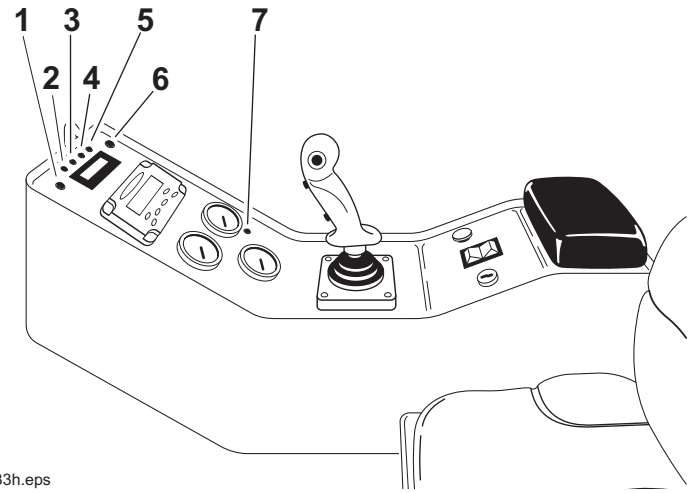
j07om034h.eps

1. Drilling fluid flowmeter
2. Thrust pressure gauge
3. Drilling fluid pressure gauge
4. Rotation pressure gauge

Item	Description	Notes
1. Drilling fluid flowmeter  c00ic050h.eps	Displays approximate rate of drilling fluid flow and records amount of drilling fluid used.	**IMPORTANT:** Monitor the flowmeter and drilling fluid pressure gauge carefully to see if values are rising or falling at the same time. If they are not, nozzle might be plugged.
2. Thrust pressure gauge  c00ic047h.eps	Displays hydraulic fluid pressure to thrust motor during thrust and pullback.	

Item	Description	Notes
3. Drilling fluid pressure gauge  c00ic048h.eps	Displays drilling fluid pressure in the drilling fluid hard line.	**IMPORTANT:** Monitor this gauge and drilling fluid flowmeter carefully to see if values are rising or falling at the same time. If they are not, nozzle might be plugged.
4. Rotation pressure gauge  c00ic049h.eps	Displays hydraulic fluid pressure to rotation motor when spindle is turned clockwise.	Inner rotation pressure is displayed when inner rotation is on and front wrench is open. Outer rotation pressure is displayed when front wrench is closed and during backreaming.

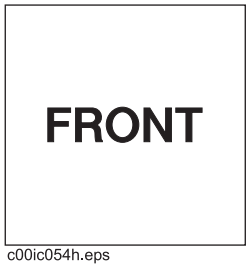
Lights

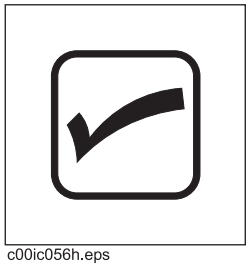
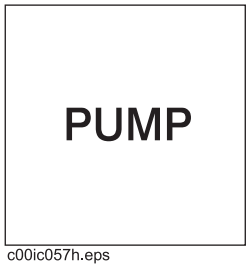


j07om033h.eps

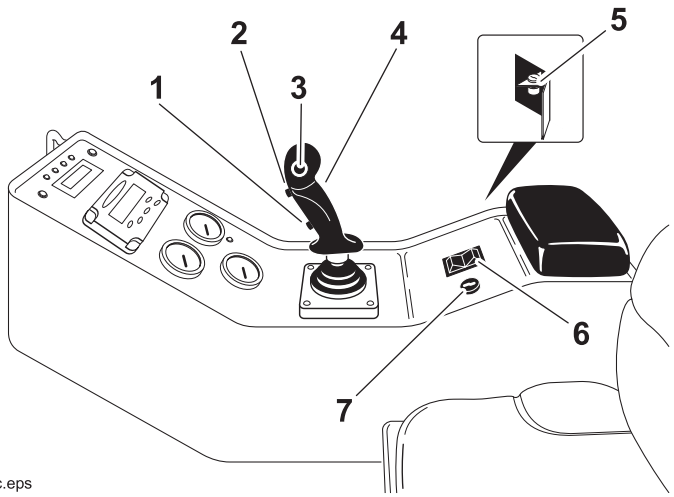
1. Diagnostic light (red)
2. Rear home status light
3. Shuttle home status light
4. Front home status light
5. Front wrench status light
6. Control cycle light (green)
7. Drilling fluid pump status light

Item	Description	Notes
1. Diagnostic light (red) c00ic051h.eps	If system is OK, light should be off. If system may not be getting power, light should be on. If a non-essential diagnostic code is recorded, light should flash on and off for 10 seconds. If an essential diagnostic code is recorded, light should flash on for three seconds and off for half a second.	See "Machine Diagnostic Codes" on page 152.

Item	Description	Notes
2. Rear home status light c00ic052h.eps	If carriage is at rear of drill frame, light should be on. If carriage is away from rear of drill frame, light should be off.	
3. Shuttle home status light c00ic053h.eps	If shuttle is retracted, light should be on. If shuttle is extended, light should be off.	
4. Front home status light  c00ic054h.eps	If carriage is at front of drill frame, light should be on. If carriage is away from front of drill frame, light should be off.	
5. Front wrench status light c00ic055h.eps	If front wrench is closed, light should be on. If front wrench is open, light should be off.	

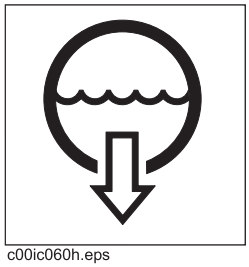
Item	Description	Notes
6. Control cycle light (green)  c00ic056h.eps	If nothing is being controlled, light should be off. If system is waiting for an action before starting cycle, light should flash on and off. If something is being controlled, light should be on. If control cycle is interrupted, light should flash twice quickly.	
7. Drilling fluid pump status light 
 c00ic057h.eps	If pump is on, light should be on. If pump is off, light should be off.	

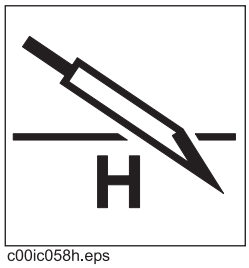
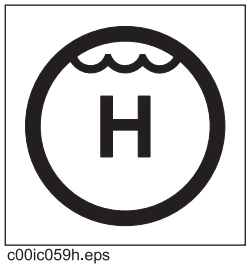
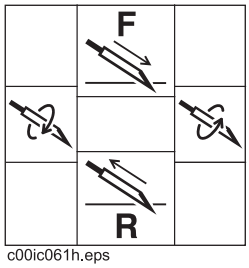
Controls

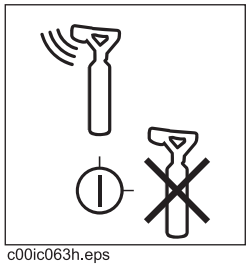
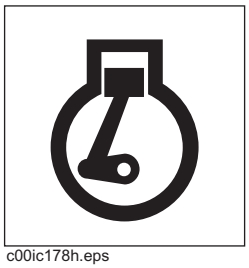
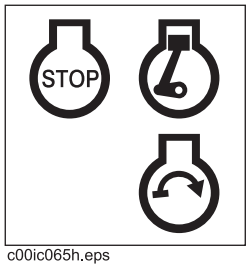


j13om003c.eps

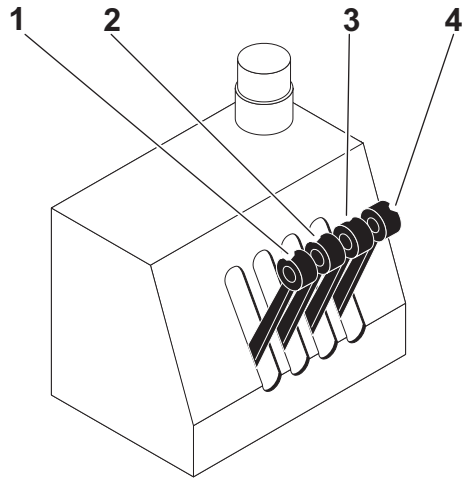
1. Drilling fluid pump switch
2. Dual speed carriage/Two-speed ground drive control
3. Drilling fluid quick fill switch
4. Track and carriage control
5. Tracker control key
6. Engine shutdown override control
7. Ignition switch

Item	Description	Notes
1. Drilling fluid pump switch  c00ic060h.eps	To turn on, press once. To turn off, press once.	

Item	Description	Notes
2. Dual speed carriage/ Two-speed ground drive control  c00ic058h.eps	Carriage travel speed: • To increase, push and hold. • To return to normal carriage speed, release. Ground drive speed: • For high ground drive speed, push once. • To return to low ground drive speed, push once.	Use during bore or pullback **when no pipe is in spindle** to save time. **IMPORTANT:** Drill/Park/Drive switch must be in **drill** position. Use **when driving straight.** **IMPORTANT:** Drill/Park/Drive switch must be in **drive** position. Unit will be in low speed each time unit is started.
3. Drilling fluid quick fill switch  c00ic059h.eps	For full pump flow to fill pipe with fluid, press and hold. To return fluid flow to flow control setting, release.	
4. Track and carriage control  c00ic061h.eps	Track control: • To move forward, push. • To move backward, pull. • To steer, move light or left while moving. Carriage control: • To move carriage forward, push. • To move carriage backward, pull. • To rotate spindle counterclockwise (breakout), move right. • To rotate spindle clockwise (makeup), move left.	**IMPORTANT:** Drill/Park/Drive switch must be in **drive** position. See "Steer Unit" on page 82 for more information. **IMPORTANT:** Drill/Park/Drive switch must be in **drill** position. See "Prime Drilling Fluid Pump" on page 94 for more information.

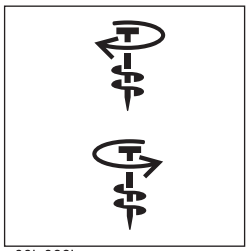
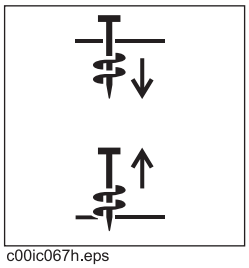
Item	Description	Notes
5. Tracker control key  c00ic063h.eps	To allow tracker operator to stop thrust and rotation, move key to enable position (up). To override tracker control mode, move key to disable position (right).	**IMPORTANT:** Remove key and keep in tracker operator's possession. See "Tracker Control" on page 131.
1. Engine shutdown override control  c00ic178h.eps	Press to delay engine shutdown for 30 seconds after cycling ignition switch to STOP.	This control allows a temporary override of engine shutdown. **NOTICE:** After 30 seconds, engine will again shut down unless fault condition has been cleared on diagnostic gauge. **IMPORTANT:** See "Tier 3 Engine" on page 157 for more information on Tier 2 operation.
2. Ignition switch  c00ic065h.eps	To start engine, insert key and turn clockwise. To stop engine, turn key counterclockwise.	**IMPORTANT:** If wrenches are engaged when engine is stopped with ignition switch, wrenches will release and then engage when unit is started.

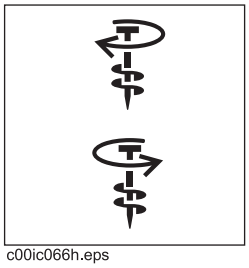
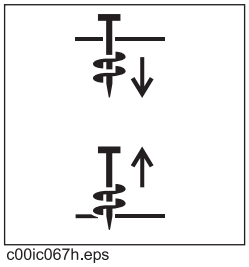
Anchoring System Console



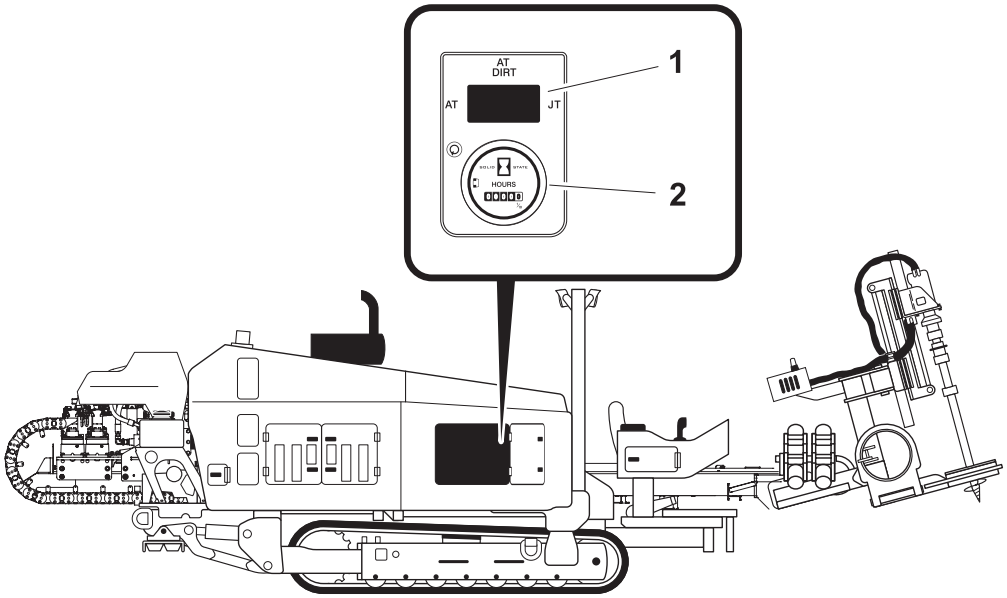
j07om041h.eps

1. Left rotation control
2. Left thrust control
3. Right rotation control
4. Right thrust control

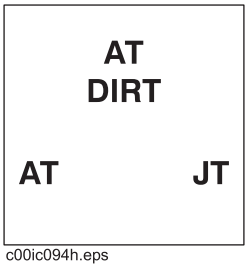
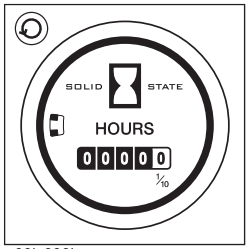
Item	Description	Notes
1. Left rotation control  c00ic066h.eps	To drive anchor, push. To remove anchor, pull.	
2. Left thrust control  c00ic067h.eps	To move anchor down, push. To move anchor up, pull.	

Item	Description	Notes
3. Right rotation control  c00ic066h.eps	To drive anchor, push. To remove anchor, pull.	
4. Right thrust control  c00ic067h.eps	To move anchor down, push. To move anchor up, pull.	

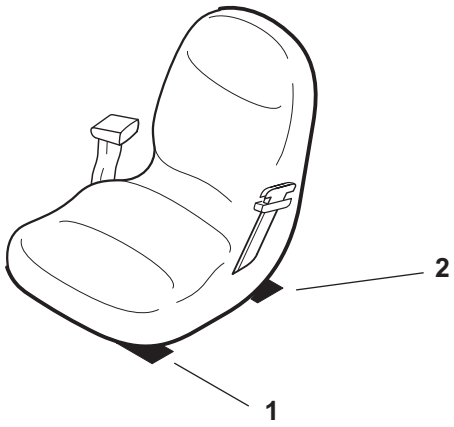
JT/AT System



1. Mode selector switch
2. Inner rotation hourmeter

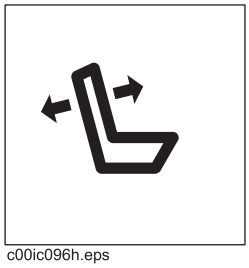
Item	Description	Notes
1. Mode selector switch  c00ic094h.eps	To select AT mode, press left. To select AT DIRT mode, move to center. To select JT mode, press right.	Use AT or AT DIRT drilling mode when using AT pipe with inner shaft. Use JT drilling mode when using JT pipe without inner shaft. **IMPORTANT:** See "Prepare Drilling Unit" on page 79 for how to set up unit for each drilling mode.
2. Inner rotation hourmeter  c00ic090h.eps	Displays inner rotation operating time.	Use these times to schedule service for downhole tool and inner shaft. See "Service" on page 175.

Seat

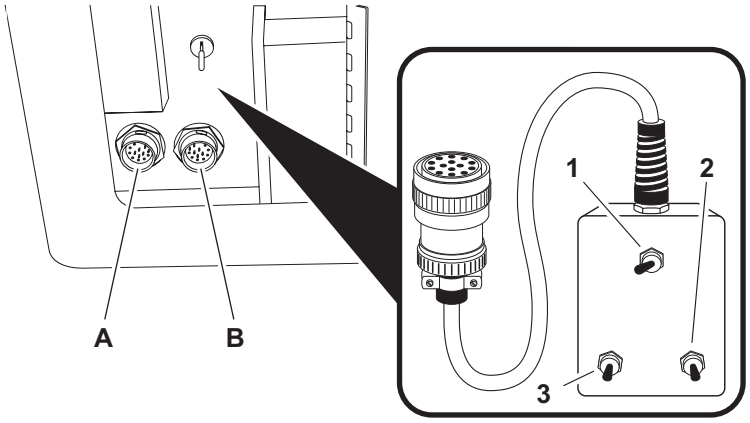


j07om045h.eps

1. Seat slide control
2. Seat recline control

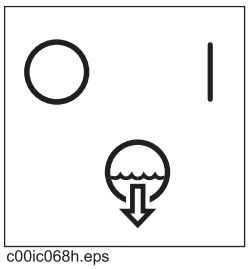
Item	Description	Notes
1. Seat slide control c00ic095h.eps	To slide forward or backward, move left. To lock seat in position, move right.	
2. Seat recline control  c00ic096h.eps	To recline or raise seatback, lift. To lock seatback in position, release.	

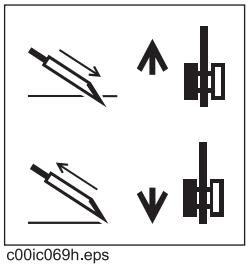
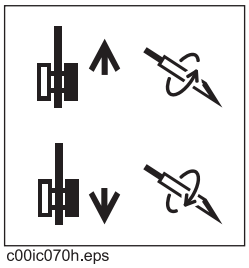
Override Box



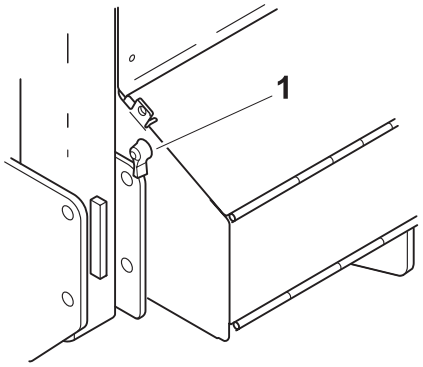
j07om038h.eps

1. Drilling fluid flow override switch
2. Thrust/pullback or left track override switch
3. Rotation or right track override switch

Item	Description	Notes
1. Drilling fluid flow override switch  c00ic068h.eps	To turn fluid on, move right. To turn fluid off, move left.	Connect to drill connector (B) to control fluid flow.

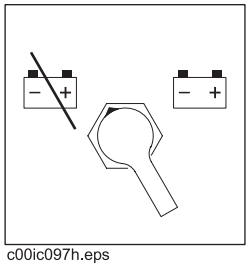
Item	Description	Notes
2. Thrust/pullback or left track override switch  c00ic069h.eps	For thrust or to move track forward, move up. For pullback or to move track backward, move down.	Connect to drill connector (B) to control thrust/pullback. Connect to drive connector (A) to control left track. **IMPORTANT:** When connected to connector (A), drill fluid switch functions as an operator presence switch.
3. Rotation or right track override switch  c00ic070h.eps	For counterclockwise rotation or to move track forward, move up. For clockwise rotation or to move track backward, move down.	Connect to drill connector (B) to control rotation. Connect to drive connector (A) to control right track. **IMPORTANT:** When connected to connector (A), drill fluid switch functions as an operator presence switch.

Battery

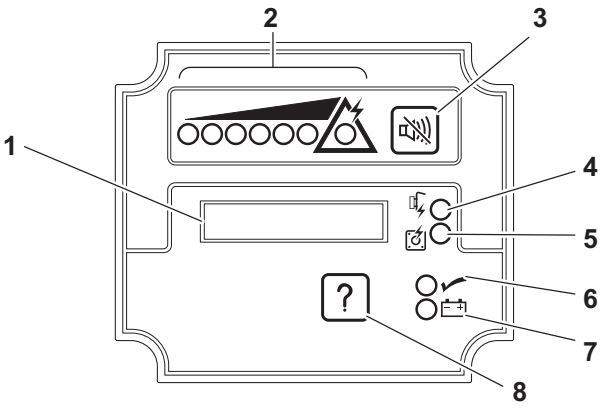


j07om001c.eps

1. Battery disconnect switch

Item	Description	Notes
1. Battery disconnect switch  c00ic097h.eps	To disconnect, turn switch counterclockwise. To connect, turn switch clockwise.	**IMPORTANT:** Use when servicing unit and during long-term storage.

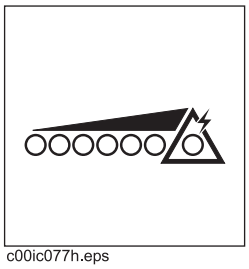
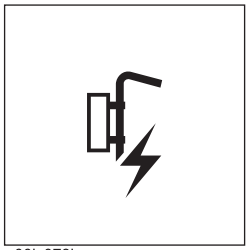
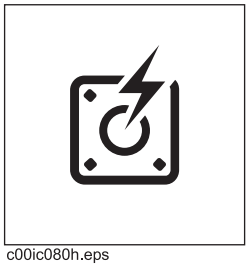
ESID

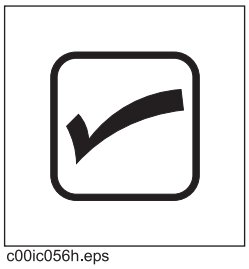
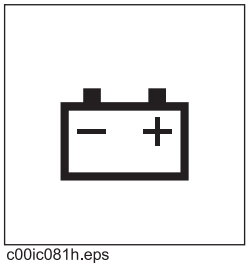


j07om042h.eps

1. Alphanumeric display
2. Strike indicator
3. Alarm interrupt button
4. Voltage problem indicator
5. Current problem indicator
6. OK indicator
7. Electrical power supply indicator
8. Self test button

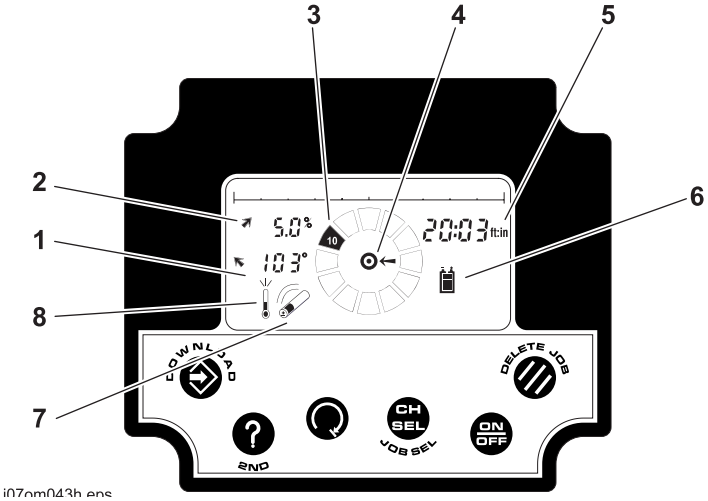
Item	Description	Notes
1. Alphanumeric display	Display amount of current and voltage being detected as a percentage of strike condition. The line with the "V" shows voltage reading and the line with the "A" shows current reading.	

Item	Description	Notes
2. Strike indicator  c00ic077h.eps	Red lights come on as values in display increase. Light in triangle represents strike warning condition and will trigger alarm(s) and strobe(s). Remember that system can go from one or two lights to an electric strike immediately.	**NOTICE:** The ESID does not indicate proximity to electric lines. System will activate only when voltage and/or amperage detected at the drilling unit are above threshold minimum limits.
3. Alarm interrupt button c00ic078h.eps	To turn off strike alarm at drilling unit, press.	
4. Voltage problem indicator  c00ic078h.eps	Red light indicates a voltage indicator problem.	See "Troubleshoot Strike System" on page 120.
5. Current problem indicator  c00ic080h.eps	Red light indicates a current indicator problem.	See "Troubleshoot Strike System" on page 120.

Item	Description	Notes
6. OK indicator  c00ic056h.eps	Green light means system self test detected no problems. Strike system is ready to operate.	
7. Electrical power supply indicator  c00ic081h.eps	Green light means control box has sufficient electrical power for operation. Strike system is ready to operate if OK indicator is also on.	
8. Self test button c00ic075h.eps	To start manual self test, press. To reset system after a strike has been detected, press.	Checks all systems and circuits except voltage limiter. **NOTICE:** See "If an Electric Line is Damaged" on page 16.

750/752 Display

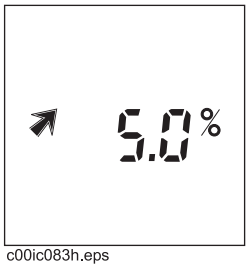
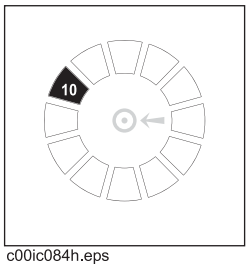
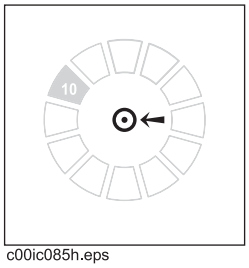
Indicators

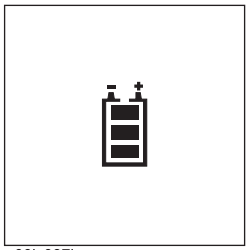
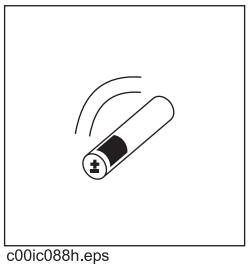
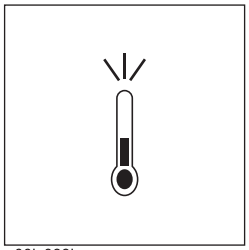


1. Beacon temperature display
2. Pitch/slope indicator and percentage indicator
3. Roll indicator
4. Target indentifier indicator
5. Depth estimate
6. Display battery status indicator
7. Beacon battery status indicator
8. Beacon temperature indicator

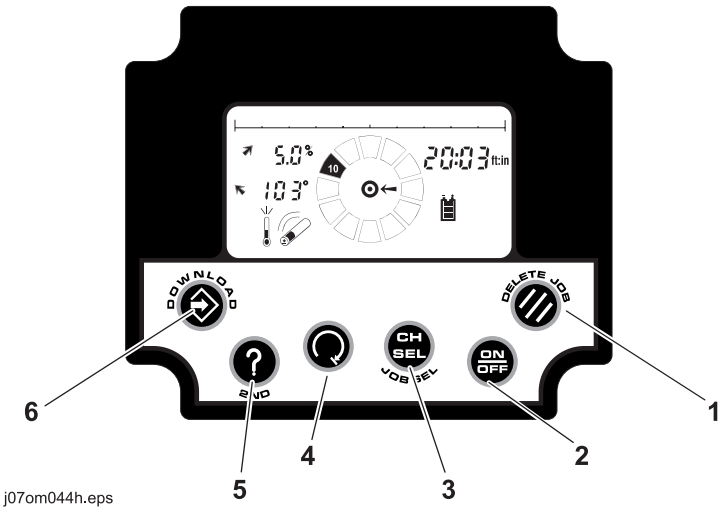
IMPORTANT: Some items operate differently depending where data is being saved. **Internal** refers to pipe data being saved to 750 Display memory. **External** refers to pipe data being sent to a properly connected laptop computer running a version of Trac Management System software.

Item	Description	Notes
1. Beacon temperature display c00ic286h.eps	Indicates beacon temperature in degrees Centigrade and degrees Farenheit.	

Item	Description	Notes
2. Pitch/slope indicator and percentage indicator  c00ic083h.eps	Indicates pitch beacon percent of grade.	**Internal**: shows pipe label and stored pitch. **External**: shows desired pitch.
3. Roll indicator  c00ic084h.eps	Indicates beacon roll angle.	
4. Target identifier indicator  c00ic085h.eps	Indicates approximate beacon location.	Only one set of arrows is active at a time.
5. Depth estimate c00ic086h.eps	Indicates beacon depth estimate.	**Internal**: shows job number and stored depth. **External**: shows desired depth.

Item	Description	Notes
6. Display battery status indicator  c00ic087h.eps	Indicates display power from drilling unit.	If all five bars are not showing, check display power connections.
7. Beacon battery status indicator  c00ic088h.eps	Indicates beacon battery status.	See beacon instruction sheet.
8. Beacon temperature indicator  c00ic089h.eps	Indicates beacon temperature.	See beacon instruction sheet.

Controls

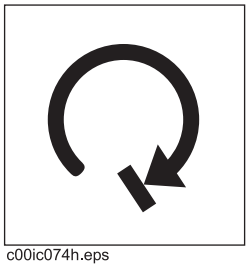


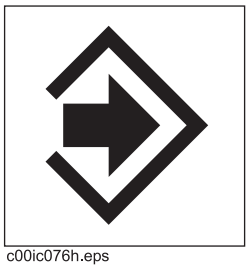
j07om044h.eps

1. Delete button
2. On/Off button
3. Channel select button
4. Roll stop button
5. Recall button
6. Store button

IMPORTANT: Some items operate differently depending where data is being saved. **Internal** refers to pipe data being saved to 750 Display memory. **External** refers to pipe data being sent to a properly connected laptop computer running a version of Trac Management System software.

Item	Description	Notes
1. Delete button c00ic071h.eps	To delete current pipe, press. **Second function:** To delete all jobs in internal logging memory, press with Recall button.	Previous pipe number will appear in numeric display when data is deleted.

Item	Description	Notes
2. On/Off button c00ic112h.eps	To turn on, press. To turn off, press again.	
3. Channel select button c00ic073h.eps	To display current channel, press and release. To switch channels, press and hold. **Second function:** To start a new job, press with Recall button. "Init" and job number will be displayed.	Unit defaults to channel one each time unit is turned on. **IMPORTANT:** Make sure display and tracker are set to the same channel.
4. Roll stop button  c00ic074h.eps	This feature is not yet available.	
5. Recall button c00ic075h.eps	To see data about pipe, press and release. **Second function:** To access second functions, press with other buttons.	**Internal**: shows data about previous pipe. **External**: shows data about next pipe.

Item	Description	Notes
6. Store button  c00ic076h.eps	To display serial number, press and hold while pressing on/off button. To store current pipe data, press. **Second function:** To download all jobs stored in internal logging memory: • Press with Recall button • Connect display to PC running Trac Management System software.	Pipe number will appear in numeric display when data is stored. **IMPORTANT:** Pipe data cannot be stored without a valid depth estimate.

Operation Overview

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Drilling 61

Backreaming 62

Leaving Jobsite 62

Storing Equipment 62

Planning

1. Gather information about jobsite. See page 65.
2. Inspect jobsite. See page 66.
3. Classify jobsite. See page 68.
4. Plan bore path. See page 70.
5. Select drilling mode based on jobsite conditions. See page 78.
6. Check supplies and prepare equipment. See page 76.
7. Load equipment. See page 87.

Setting Up at Jobsite

1. Prepare jobsite. See page 75.
2. Unload drilling unit from trailer. See page 86.
3. Assemble drill string. See page 97.
4. Position drilling unit and frame. See page 93.
5. Assemble strike system. See page 119.
6. Anchor drilling unit. See page 115.
7. Connect fluid system. See page 93.
8. Calibrate tracker with beacon that will be installed in beacon housing. See tracker operator's manual.

Drilling

1. Start system. See page 93.
2. Engage tracker control if desired. See page 131.
3. Drill first pipe. See page 100.
   - JT mode
   - AT dirt mode
   - AT mode
4. Swab the hole to remove cuttings (AT mode only). See page 101.
5. Record bore path. See page 106.
6. Enable automated pipeloader system. See page 101.
7. Add pipe. See page 102.
8. Drill remaining pipes in pipe box.
   - Correct direction. See page 104.
   - Engage cruise control. See page 151.
9. Remove empty pipe box and add full box (see page 145) or add up to a single row of drill pipe to empty box (see page 147) to complete bore.
10. Surface drill head. See page 106.
    - Remove drill head.
    - Grease downhole tool (AT mode).

Backreaming

1. Assemble backream string. See page 107.
2. Start drilling unit and adjust throttle.
3. Set drilling fluid flow. Check that fluid flows through all nozzles. See page 134.
4. Remove pipe from bore. See page 109.
5. Remove full pipe box and add empty box (see page 145) or remove up to a single row of drill pipe from full box (see page 147) to complete backream.
6. Remove pullback device. See page 111.

Backreaming Tips

- Plan backreaming job before drilling. Plan bore path as straight as possible. Check bend limits of pullback material. Check that appropriate pullback devices are on hand.
- Keep all bends as gradual as possible.
- Drilling fluid quality is a key factor in backreaming success. Contact your Ditch Witch dealer for information on testing water, selecting additives, and mixing drilling fluid.
- Backreaming requires more fluid than drilling. Make sure enough fluid is used.

Leaving Jobsite

1. Remove downhole tools. See page 111.
2. Remove anchors. See page 117.
3. Rinse unit and downhole tools. See page 172.
4. Disassemble strike system and disconnect from fluid system. See page 172.
5. Stow tools. See page 173.
6. Load unit onto trailer. See page 87.

Storing Equipment

1. For cold weather storage, antifreeze drilling unit. See page 170.
2. For long-term storage, disconnect battery disconnect switch.

Prepare

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- Plan for Emergency Services 65

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Classify Jobsite. 68

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Gather Information

A successful job begins before the bore. The first step in planning is reviewing information already available about the job and jobsite.

Review Job Plan

Review blueprints or other plans and make sure you have taken bore enlargement during backreaming and pullback into account. Check for information about existing or planned structures, elevations, or proposed work that may be taking place at the same time.

Notify One-Call Services

Call area One-Call or similar services and have existing lines located and marked. Call any utilities in your area that do not subscribe to One-Call.

Examine Pullback Material

Ask for a sample of the material you will be pulling back. Check its weight and stiffness. Contact the manufacturer for bend radius information. Check that you have appropriate pullback devices.

Arrange for Traffic Control

If working near a road or other traffic area, contact local authorities about safety procedures and regulations.

Plan for Emergency Services

Have the telephone numbers for local emergency and medical facilities on hand. Check that you will have access to a telephone.

Inspect Site

Inspect jobsite before transporting equipment. Check for the following:

- overall grade or slope
- changes in elevation such as hills or open trenches
- obstacles such as buildings, railroad crossings, or streams
- signs of utilities (See "Inspect Jobsite" on page 68.)
- traffic
- access
- soil type and condition
- water supply
- sources of locator interference (rebar, railroad tracks, etc.)

Take soil samples from several locations along bore path to determine best bit and backreamer combinations.

Identify Hazards

Identify safety hazards and classify jobsite. See "Classify Jobsite" on page 68.

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

NOTICE:

- Wear personal protective equipment including hard hat, safety eye wear, and hearing protection.
- Do not wear jewelry or loose clothing.
- Notify One-Call and companies which do not subscribe to One-Call.
- Comply with all utility notification regulations before digging or drilling.
- Verify location of previously marked underground hazards.
- Mark jobsite clearly and keep spectators away.

Remember, jobsite is classified by hazards in place -- not by line being installed.

Select Start and End Points

Select one end to use as a starting point. Consider the following when selecting a starting point:

Slope

Fluid system should be parked on a level site. Consider how slope will affect drilling unit setup, bending pipe, and fluid flow out of hole.

Traffic

Vehicle and pedestrian traffic must be a safe distance from drilling equipment. Allow at least 10' (3 m) buffer zone around equipment.

Space

Check that starting and ending points allow enough space for gradual pipe bending. See "Minimum Setback" on page 73.

Check that there is enough space to work and to set up electric strike system.

Comfort

Consider shade, wind, fumes, and other site features.

Drill downhill when possible so fluid will flow away from drilling unit.

Classify Jobsite

Inspect Jobsite

- Follow U.S. Department of Labor regulations on excavating and trenching (Part 1926, Subpart P) and other similar regulations.
- Contact One-Call (888-258-0808) and any utility companies which do not subscribe to One-Call.
- Inspect jobsite and perimeter for evidence of underground hazards, such as:
  - "buried utility" notices
  - utility facilities without overhead lines
  - gas or water meters
  - junction boxes
  - drop boxes
  - light poles
  - manhole covers
  - sunken ground
- Have an experienced locating equipment operator sweep area within 20' (6 m) to each side of bore path. Verify previously marked line and cable locations.
- Mark location of all buried utilities and obstructions.
- Classify jobsite.

Select a Classification

Jobsites are classified according to underground hazards present.

If working . . .	then classify jobsite as . . .
within 10' (3 m) of a buried electric line	electric
within 10' (3 m) of a natural gas line	natural gas
in sand, granite, or concrete which is capable of producing crystalline silica (quartz) dust	crystalline silica (quartz) dust
within 10' (3 m) of any other hazard	other

NOTICE: If you have any doubt about jobsite classification, or if jobsite might contain unmarked hazards, take steps outlined previously to identify hazards and classify jobsite before working.

Apply Precautions

Once classified, precautions appropriate for jobsite must be taken.

Electric Jobsite Precautions

In addition to using a directional drilling system with an electric strike system, use one or both of these methods.

- Expose line by careful hand digging or soft excavation. Use beacon to track bore path.
- Have service shut down while work is in progress. Have electric company test lines before returning them to service.

Natural Gas Jobsite Precautions

In addition to using a directional drilling system and positioning equipment upwind from gas lines, use one or both of these methods.

- Expose lines by careful hand digging or soft excavation. Use beacon to track bore path.
- Have gas shut off while work is in progress. Have gas company test lines before returning them to service.

Crystalline Silica (Quartz) Dust Precautions

Follow OSHA or other guidelines for exposure to crystalline silica when trenching, sawing or drilling through material that might produce dust containing crystalline silica (quartz).

Other Jobsite Precautions

You may need to use different methods to safely avoid other underground hazards. Talk with those knowledgeable about hazards present at each site to determine which precautions should be taken or if job should be attempted.

Plan Bore Path

Plan the bore path, from entry to end, before drilling begins. The Ditch Witch **Trac Management System Plus** is available for planning your bore path. This special software can be run in the field using a laptop computer equipped with Windows® 95 or higher operating system. See your Ditch Witch dealer for details.

If not using Trac Management System Plus, mark the bore path on the ground with spray paint or flags, or record it on paper for operator reference.

For complicated bores, consult an engineer. Have the jobsite surveyed and bore path calculated. Be sure the engineer knows minimum entry pitch, bend limits of drill pipe, bend and tension limits of pullback material, pipe lengths, and location of all underground utilities.

For less complicated bores, plan the bore based on four measurements:

- recommended bend limit
- entry pitch
- minimum setback
- minimum depth

IMPORTANT: See the following pages for more information about these measurements. If not using Trac Management System Plus, see "Bore Path Calculator" on page 74 and use these measurements to help plan your bore.

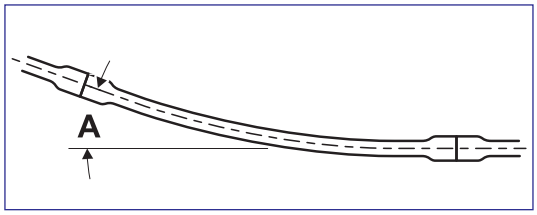
Recommended Bend Limits

Ditch Witch drill pipes are designed to bend slightly during operation. Slight bending allows for steering and correcting direction. Bending beyond recommended limits will cause damage that might not be visible. This damage adds up and will later lead to sudden drill pipe failure.

IMPORTANT: Consider recommended bend limits during any bend, not just during bore entry.

Pipe Pitch

Ditch Witch drill pipe is tested to bend at a maximum percent pitch. For JT4020 All Terrain drill pipe, make sure pitch (A) changes no more than **5%** over the full length of each pipe.



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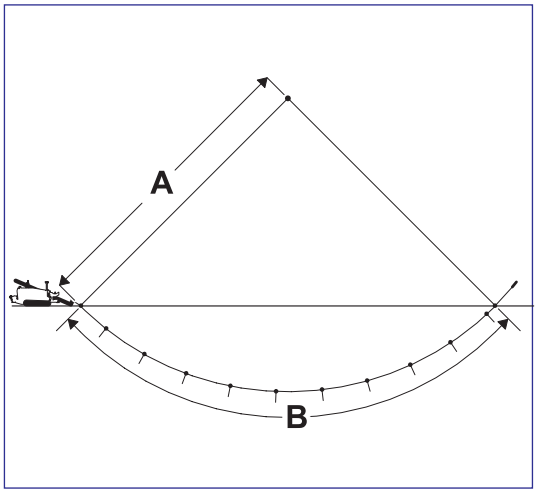
NOTICE: Bending drill pipe more sharply than recommended will damage pipe and cause failure over time. Changes in pitch must be **equally distributed** over the length of a pipe. Maximum changes in pitch within 1-2' (300-600 mm) of pipe create sharp bends that will damage pipe.

Monitor the pitch of each pipe with the 750 Display on the operator's console. See "750/752 Display" on page 53.

Bend Radius

JT4020 All Terrain drill pipes have a tested minimum bend radius of **300' (91.4 m)**. This means that a 90-degree bend in the bore path:

- has a radius (A) of 300' (91.4 m)
- requires approximately 471' (143.6 m) of drill pipe (B).



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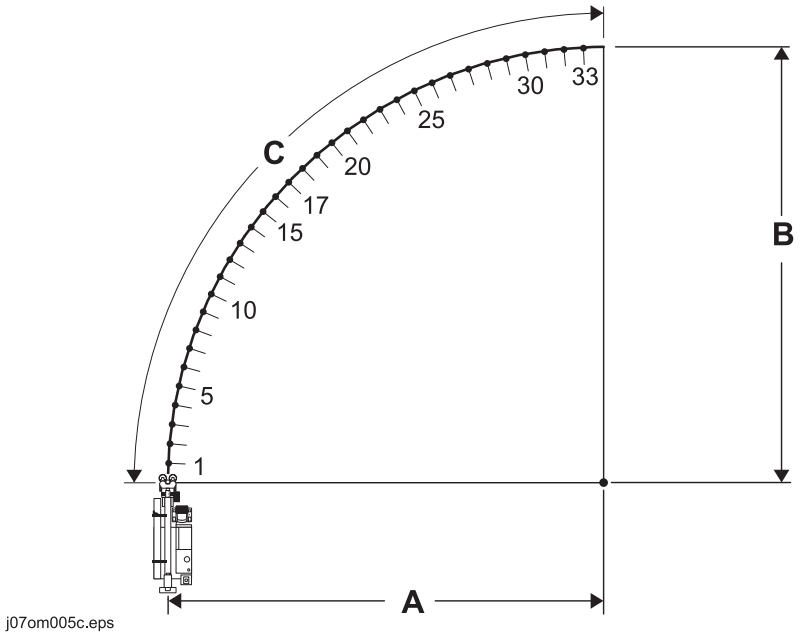
NOTICE: Bending drill pipe more sharply than recommended will damage the pipe and cause failure over time.

- If bend radius is reduced, drill pipe life is reduced.
- If bend radius is increased, drill pipe life is increased.

IMPORTANT: Use the charts on the next page to keep bends within safe limits.

Pipe-By-Pipe Bend Limits

Pipe (C)	Forward (B)	Deflection (A)	Pipe (C)	Forward (B)	Deflection (A)
1	14 ft 3 in (4.3 m)	0 ft 4 in (0.1 m)	**18**	226 ft 6 in (69.0 m)	103 ft 3 in (31.5 m)
2	28 ft 6 in (8.7 m)	1 ft 4 in (0.4 m)	**19**	235 ft 7 in (71.8 m)	114 ft 3 in (34.8 m)
3	42 ft 8 in (13.0 m)	3 ft 1 in (0.9 m)	**20**	244 ft 2 in (74.4 m)	125 ft 8 in (38.3 m)
4	56 ft 8 in (17.3 m)	5 ft 5 in (1.7 m)	**21**	252 ft 2 in (76.9 m)	137 f 5 in (41.9 m)
5	70 ft 8 in (21.5 m)	8 ft 5 in (2.6 m)	**22**	259 ft 7 in (79.1 m)	149 ft 7 in (45.6 m)
6	84 ft 5 in (25.8 m)	12 ft 1 in (3.7 m)	**23**	266 ft 5 in (81.2 in)	162 ft 2 in (49.4 m)
7	98 ft 0 in (29.9 m)	16 ft 5 in (5.0 m)	**24**	272 ft 8 in (83.1 m)	174 ft 11 in (53.3 m)
8	111 ft 4 in (33.9 m)	21 ft 5 in (6.5 m)	**25**	278 ft 4 in (84.8 m)	188 ft 0 in (57.3 m)
9	124 ft 6 in (37.9 m)	27 ft 0 in (8.2 m)	**26**	283 ft 4 in (86.4 m)	201 ft 5 in (61.4 m)
10	137 ft 3 in (41.9 m)	33 ft 3 in (10.1 m)	**27**	287 ft 8 in (87.7 m)	215 ft 0 in (65.5 m)
11	149 ft 10 in (45.7 m)	40 ft 1 in (12.2. m)	**28**	291 ft 5 in (88.8 m)	228 ft 9 in (69.7 m)
12	162 ft 0 in (49.4 m)	47 ft 6 in (14.5 m)	**29**	294 ft 6 in (89.8 m)	242 ft 8 in (74.0 m)
13	173 ft 10 in (53.0 m)	55 ft 6 in (16.9 m)	**30**	296 ft 10 in (90.5 m)	256 ft 9 in (78.3 m)
14	185 ft 3 in (56.5 m)	64 ft 0 in (19.5 m)	**31**	298 ft 7 in (91.0 m)	270 ft 10 in (82.6 m)
15	196 ft 3 in (59.8 m)	73 ft 1 in (22.3 m)	**32**	299 ft 8 in (91.3 m)	285 ft 1 in (86.9 m)
16	206 ft 10 in (63.0 m)	82 ft 8 in (25.2 m)	**33**	300 ft 0 in (91.4 m)	300 ft 0 in (91.4 m)
17	216 ft 11 in (66.1 m)	92 ft 9 in (28.3 m)			



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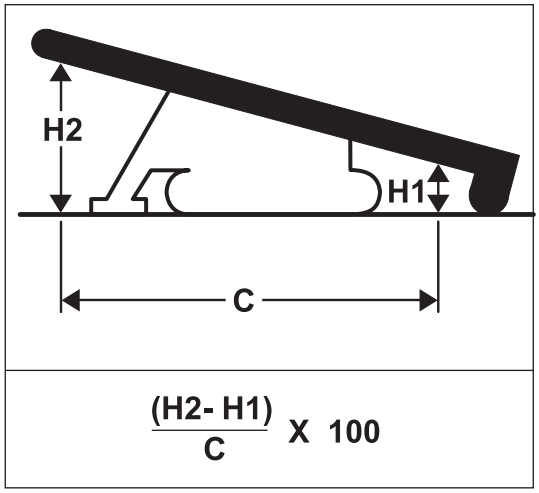
Entry Pitch

Entry pitch is the slope of the drill frame compared with the slope of the ground. Determine entry pitch one of two ways:

1. **With Pitch Beacon**
   - Lay pitch beacon on the ground and read pitch.
   - Lay pitch beacon on drill frame and read pitch.
   - Subtract ground pitch from drilling unit pitch.
2. **With Measurements**
   - Measure from the ground to front end of drill frame (H1).
   - Measure from the ground to back end of frame (H2).
   - Subtract (H1) from (H2). Record this number.
   - Measure the distance between front and back points (C).
   - Divide (H2-H1) by (C), then multiply by 100. This is your pitch.



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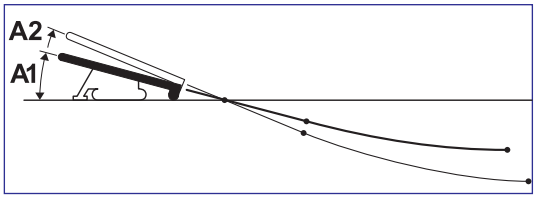
IMPORTANT: A shallow entry pitch (A1) allows you to reach horizontal sooner and with less bending. Increasing entry pitch (A2) makes bore path longer and deeper.



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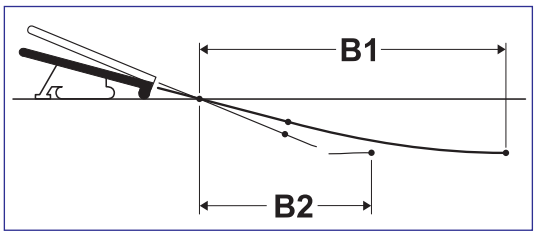
Minimum Setback

Setback is the distance from the entry point to where pipe becomes horizontal (B1).

NOTICE: If setback is too small (B2), you will exceed bend limits and damage the pipe.



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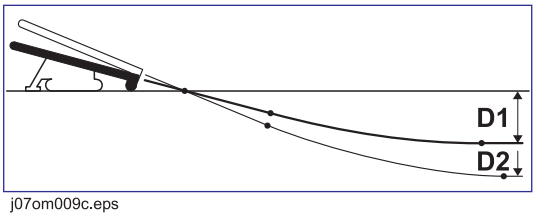
Minimum Depth



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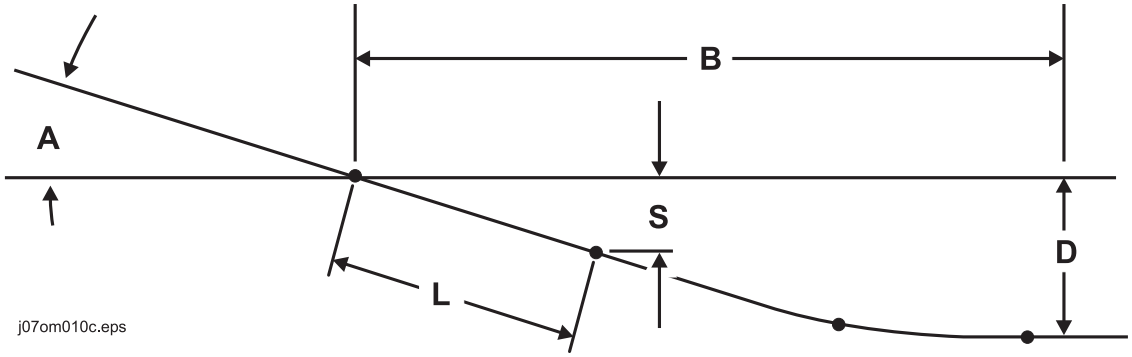
Because you must bend pipe gradually, entry pitch and bend limits determine how deep the pipe will be when it becomes horizontal. This is called the **minimum depth**.

- To reduce minimum depth (D1), reduce entry pitch. This also increases setback.
- To increase minimum depth (D2), increase entry pitch. This also reduces setback.

Bore Path Calculator

Entry pitch, setback, and minimum depth work together with bend limits to determine the bore path. To find the setback (B) and entry pitch (A) that will take you to the desired minimum depth (D), use the chart below.



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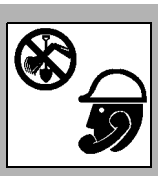
Minimum depth (D)	Entry pitch (A)	Setback (B)	Depth to begin steering (S)
8 ft 5 in (2.6 m)	-20%	71 ft 7 in (21.8 m)	2 ft 7 in (0.8 m)
9 ft 10 in (3.0 m)	-22%	77 ft 2 in (23.5 m)	2 ft 10 in (0.9 m)
11 ft 4 in (3.5 m)	-24%	82 ft 8 in (25.2 m)	3 ft 0 in (0.9 m)
12 ft 11 in (3.9 m)	-26%	88 ft 1 in (26.9 m)	3 ft 3 in (1.0 m)
14 ft 7 in (4.5 m)	-28%	93 ft 5 in (28.5 m)	3 ft 6 in (1.1 m)
16 ft 5 in (5.0 m)	-30%	98 ft 8 in (30.1 m)	3 ft 9 in (1.1 m)
18 ft 3 in (5.6 m)	-32%	103 ft 10 in (31.7 m)	4 ft 0 in (1.2 m)

IMPORTANT: Numbers in table based on **300' (91.4 m) minimum bend radius**, Rockmaster housing, 6.25-in bit, and half of first drill pipe (L, totaling 13' [4 m]) in the ground before steering.

Prepare Jobsite



WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

NOTICE:

- If jobsite classification is in question or if the possibility of unmarked electric utilities exists, classify jobsite as electric.
- Cutting high voltage cable can cause electrocution. Expose lines by hand before digging.

Mark Bore Path

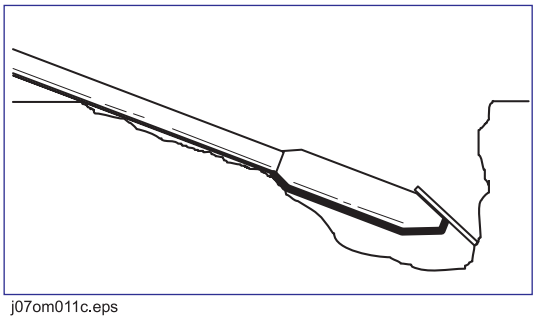
Mark your planned bore path and all located utility lines with flags or paint.

Prepare Entry Point

For bore to be successful, first pipe must be straight as it enters the ground.

To help ensure that the first pipe does not bend, dig a small starting hole so that the first pipe is drilled into a vertical surface.

To prevent bending or straining pipe, position drilling unit for straight entry.



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Check Supplies and Prepare Equipment

Check Supplies

- receiver/transmitter or tracker with spare batteries
- beacons with new and spare batteries
- two-way radios with new and spare batteries
- hydraulic wrench (see "Hydratong Wrenches" on page 139)
- transition sub
- anchoring equipment and accessories
- bits, screens, nozzles (see "Downhole Tools" on page 134)
- adapters, pipe, beacon housings
- marking flags or paint
- water and additional hoses
- fuel
- drilling fluid additives (see "Drilling Fluid" on page 126)
- spare fuses
- keys
- backreamers, swivels, pulling devices (see "Backreamers" on page 136)
- wash down hose and spray gun
- duct tape
- spray lubricant
- tool joint compound (see "Recommended Lubricants/Service Key" on page 178)
- electrically insulating boots and gloves
- personal protective equipment, such as hard hat and safety glasses
- notepad and pencil

Prepare Equipment

Fluid Levels

- fuel
- hydraulic fluid
- engine coolant
- battery charge
- engine oil

Condition and Function

- drive chains
- filters (air, oil, hydraulic)
- fluid pump
- couplers
- tires and tracks
- pumps and motors
- drilling fluid mixer
- hoses and valves
- water tanks

Select Drilling Mode

Three drilling setups are available with this unit:

- AT mode
- AT dirt mode
- JT mode

Select the best setup based on jobsite conditions.

Mode	Situation used	Downhole tools	Capabilities
AT	Rock, soft rock, other non-compressible soils. Any other situation with difficult steering because of hard soil conditions.	• All Terrain drill pipe • Rockmaster tool	• 25,000 lb (111 kN) of thrust • dither • inner rotation
AT dirt	When one bore out of several can be better or more quickly done with conventional downhole tools. This bore is such that changing to JT pipe is not practical.	• All Terrain drill pipe • beacon housing (p/n 368-822) • transition sub (p/n 401-143) • standard JT tools	• 36,000 lb (160 kN) of thrust • dither • no inner rotation
JT	Soft or intermittent soft rock or other compressible soils.	• JT drill pipe • standard JT tools	• 36,000 lb (160 kN) of thrust • no dither • no inner rotation

Once drilling mode has been selected, configure drilling unit to match mode.

Prepare Drilling Unit

AT Mode

- Verify unit has not been converted to JT mode. Ensure All Terrain saver sub, shuttle stops, pipe gripper pads, pipe guide blocks, pipe wiper, shuttle stop, wrench jaw blocks, and pipe lifter pads are installed.
- Inspect Rockmaster tool and select bit based on jobsite conditions.
- Use drill bit type anchors.
- Load All Terrain pipe and pipe box onto unit.
- Check position of rear lubricator relative to threads. Lubricator should line up with threads when pipe is fully against front of pipe box. Adjust if needed.
- Move mode selector switch to AT position.

AT Dirt Mode

- Verify unit has not been converted to JT mode. Ensure All Terrain saver sub, shuttle stops, pipe gripper pads, pipe guide blocks, pipe wiper, shuttle stop, wrench jaw blocks, and pipe lifter pads are installed.
- Use transition sub (p/n 401-143) between All Terrain pipe and beacon housing (p/n 368-822). Select soil bit based on jobsite conditions.
- Use auger type anchors if in soft soil conditions.
- Load All Terrain pipe and pipe box onto unit.
- Check position of rear lubricator relative to threads. Lubricator should line up with threads when pipe is fully against front of pipe box. Adjust if needed.
- Move mode selector switch to AT DIRT position.

JT Mode

IMPORTANT: Use conversion kit (p/n 101-136) and refer to installation instructions (p/n 051-329).

- Install saver sub, pipe gripper pads, pipe guide blocks, pipe wiper, shuttle stop, wrench jaw blocks, and pipe lifter pads sized to handle Mach 1 pipe.
- Use standard transition sub and beacon housing. Select soil bit based on jobsite conditions.
- Use auger type anchors.
- Load JT pipe and pipe box onto unit.

IMPORTANT: Do not put JT pipe into a large All Terrain pipe box. Pipe can jam and box can be damaged. Use JT pipe box.

- Check position of rear lubricator relative to threads. Lubricator should line up with threads when pipe is fully against front of pipe box. Adjust if needed.
- Move mode selector switch to JT position.

Assemble Accessories

Fire Extinguisher

If required, mount a fire extinguisher near the power unit but away from possible points of ignition. The fire extinguisher should always be classified for both oil and electric fires. It should meet legal and regulatory requirements.

Lighting Kit

If you will need additional light, plug lighting kit into provided outlet. Contact your Ditch Witch dealer for further information.

Drive

Chapter Contents

Start Unit 82

Steer Unit 82

Shut Down Unit 82

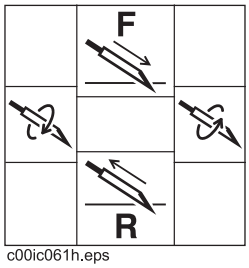
Start Unit

Standard Procedure

1. Insert key.
2. Turn ignition switch to the run position (key on, engine off). Engine preheat indicator (on setup console at operator's station) will light.
3. Wait for engine preheat indicator to go off before starting.
4. Run engine at low throttle for 5 minutes.

Steer Unit

To steer drilling unit, follow instructions for type of steering desired.



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To steer while moving forward, push forward and then move to left or right. Drilling unit will gradually turn to left or right.

To steer while moving backward, pull back and then move to left or right. Drilling unit will gradually turn to left or right.

For tight steering in low speed, move control to center position and then to a corner. Tracks will counter-rotate and turn drilling unit in a tight circle.

Shut Down Unit

1. Stop track movement.
2. Engage parking brake.
3. Run engine at low throttle for 3 minutes to cool.
4. Turn ignition switch to STOP.
5. Remove key.

Transport

Chapter Contents

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- Points 84
- Procedure 84

Haul 86

- Inspect Trailer 86
- Hitch Trailer 86
- Load 87
- Tie Down 88
- Unload 89
- Unhitch Trailer 89

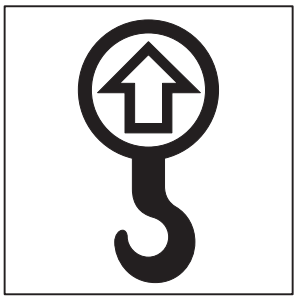
Tow 89

Lift

WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

Points

Lifting points are identified by lifting decals. Lifting at other points is unsafe and can damage machinery.



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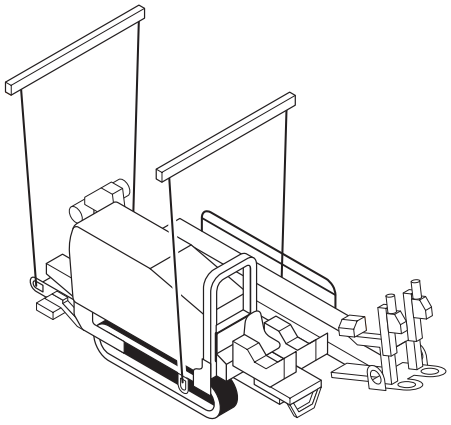
Procedure

Drilling Unit

Use a crane capable of supporting the equipment's size and weight. See “Specifications” on page 215 or measure and weigh equipment before lifting. Use four lift points. Attach securely to cross members.



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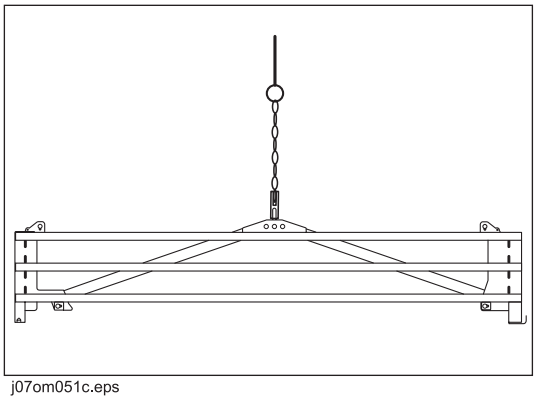
Pipe Box

Use crane capable of supporting the equipment's size and weight. See “Specifications” on page 215 or measure and weigh equipment before lifting.

NOTICE: Lift only one box of pipe at a time.

If lift pin block is not installed, see “Pipe Boxes” on page 145 for installation procedure.



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Haul

Inspect Trailer

- Check hitch for wear and cracks. Lubricate if needed.
- Check u-bolts and axles for wear. Replace if needed.
- Check fasteners for wear and tightness. Replace or tighten if needed.
- Check battery for 12V charge.
- Inspect lights for cleanliness and correct operation. Inspect reflectors and replace if needed.
- Check tire pressure. Check lug nut torque with a torque wrench. Adjust if needed.
- Ensure trailer brakes are adjusted to come on in synchronization with tow vehicle brakes.
- Check ramps and trailer bed for cracks.

Hitch Trailer

1. Back tow vehicle to trailer.
2. Put manual transmission into first or reverse gear or automatic transmission into park. Turn off ignition. Set parking brake.
3. Connect trailer drawbar, lunette or coupler to tow vehicle hitch and lock in place with lock pin. If needed, adjust drawbar, lunette or coupler height to level load.
4. Connect safety chains to tow vehicle.
5. Connect breakaway switch cable to tow vehicle. Do not connect to pintle hook or hitch ball.
6. Plug trailer electrical connector into tow vehicle connector.
7. Use jack crank to raise jack base and stow.
8. Remove wheel blocks.

Load

WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

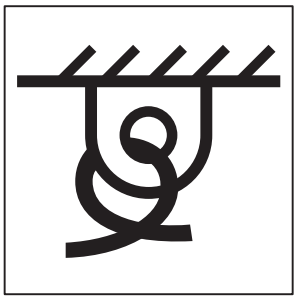
- Load and unload trailer on level ground.
- Incorrect loading can cause trailer swaying.
- Attach trailer to vehicle before loading or unloading.
- Ten to fifteen percent of total vehicle weight (equipment plus trailer) must be on tongue to help prevent trailer sway.

1. Fasten and adjust seat belt.
2. Start drilling unit engine.
3. Move drilling unit to rear of trailer and align with ramps or center of trailer bed.
4. Slow engine to low throttle and slowly drive unit onto trailer.
5. Lower stabilizers to trailer floor.
6. Lower drill frame to trailer floor.
7. Stop engine when unit is safely positioned on trailer bed.
8. Attach tiedowns to drilling unit where tiedown decals are located.

Tie Down

Points

Tiedown points are identified by tiedown decals. Securing to trailer at other points is unsafe and can damage machinery.



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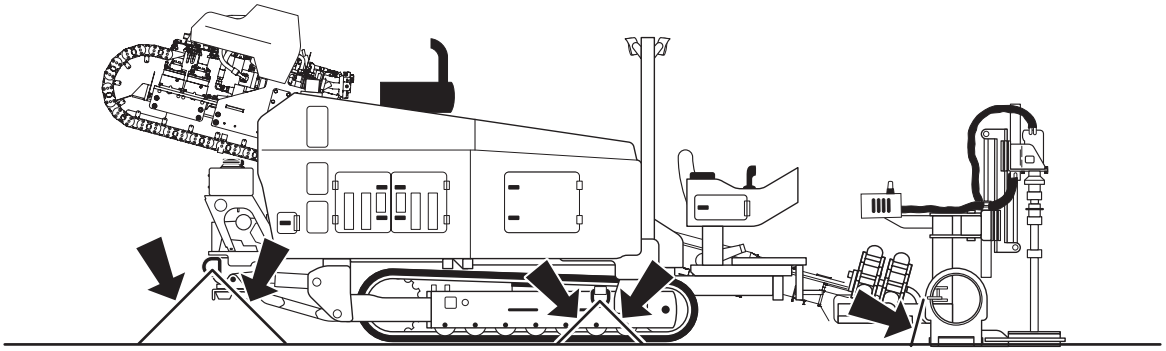
Procedure

Loop tiedowns around unit at tiedown points. Make sure tiedowns are tight before transporting.



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Unload

WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

- Load and unload trailer on level ground.
- Attach trailer to vehicle before loading or unloading.

1. Lower trailer or ramps.
2. Fasten and adjust seat belt.
3. Start drilling unit engine.
4. Remove tiedowns.
5. Raise stabilizers.
6. Raise drill frame.
7. Slow engine to low throttle and slowly back unit down trailer or ramps.

Unhitch Trailer

1. Stop tow vehicle and trailer on level ground.
2. Put manual transmission into first or reverse gear or automatic transmission into park. Turn off ignition. Set parking brake.
3. Block trailer wheels.
4. Reverse "Hitch Trailer " steps to unhitch trailer from tow vehicle.

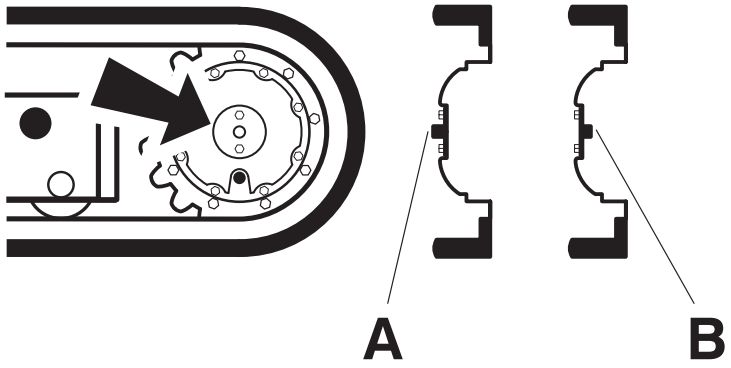
Tow

Under normal conditions, drilling unit should not be towed. If unit breaks down and towing is necessary:

- tow for short distances at less than 1 mph (1.6 km/h),
- attach chains to indicated tow points facing towing vehicle,
- use maximum towing force of 1.5 times unit weight,
- disengage track planetaries.

To disengage track planetaries, reverse small cover plate in center of planetary on each track drive.

IMPORTANT: When planetaries are disengaged, unit has no brakes.



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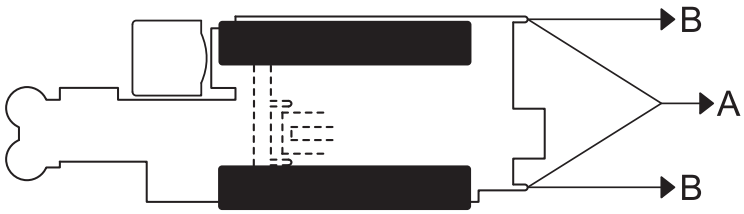
A. Normal operation B. Towing

To attach chains to tow points, determine which points are facing towing vehicle.

If **back** tow points are facing towing vehicle, choose option A or B.



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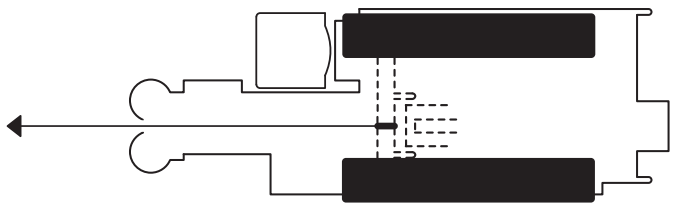
Option A: Loop chain through both tow points and attach to common cross member. Always pull straight back.

Option B: Loop chain through each tow point and attach chains to towing vehicle. Always pull straight back.

If **front** tow points are facing towing vehicle, loop chain through tow point and pull straight forward.



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Conduct a Bore

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Start System 93

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Operate Carriage Control 95

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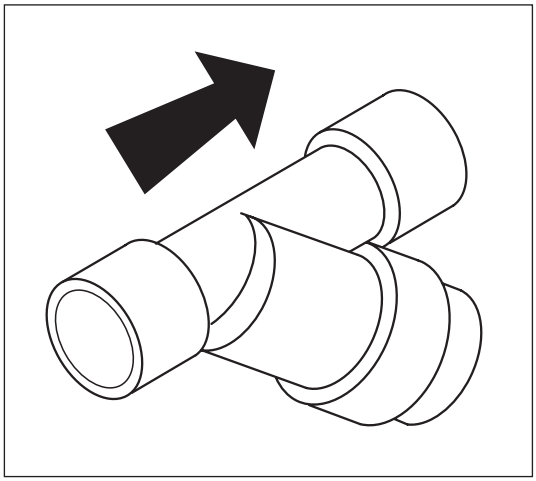
Position Equipment

1. Review bore plan and select drilling unit position and fluid unit position.
2. Move equipment into selected positions.

Connect Fluid System

1. Connect fluid hose from mixing system to drilling fluid pump. A 3" (76 mm) or larger, non-collapsable hose is required.
2. Install y-strainer between mixing unit and drilling fluid pump. Position strainer so that drilling fluid flows in the direction of the arrow. In most cases, positioning strainer at outlet of mixing unit gives best results.

IMPORTANT: Clean y-strainer regularly. See page 188.



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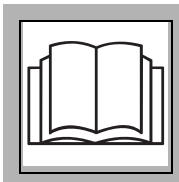
Start System

1. Start drilling unit and remote fluid unit. Allow both engines to warm up.

IMPORTANT: Ensure that mixture of drilling fluid matches drilling conditions.

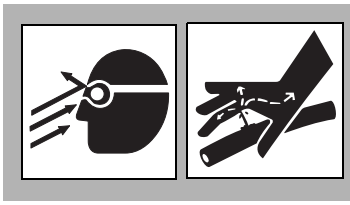
2. Enable tracker control mode if desired. See "Tracker Control" on page 131.
3. Press top of drilling unit throttle switch until engine is at full throttle.
4. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.

Prime Drilling Fluid Pump



WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE: Failure to prime the drilling fluid pump will cause flow fluctuations, which will make it difficult to control the washwand.



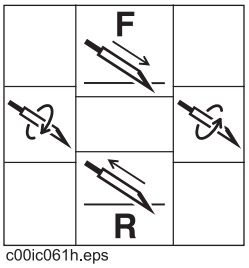
WARNING Pressurized fluid or air could pierce skin and cause injury or death. Stay away.

Prime drilling fluid pump each time the tank is changed. To prime the pump:

1. Fill drilling fluid hose and connect hose to unit.
2. Operate mixing/transfer pump at full speed for 1 - 3 minutes to discharge air from system.
3. Return mixing/transfer pump to normal operating speed and continue the bore.
4. If drilling fluid pressure surges are observed, repeat step 2.

Operate Carriage Control

The thrust/rotation control has eight positions which allow the four basic functions to be combined. The chart below summarizes functions that occur when control is put at a combined position. Operator must be in seat for control to function.



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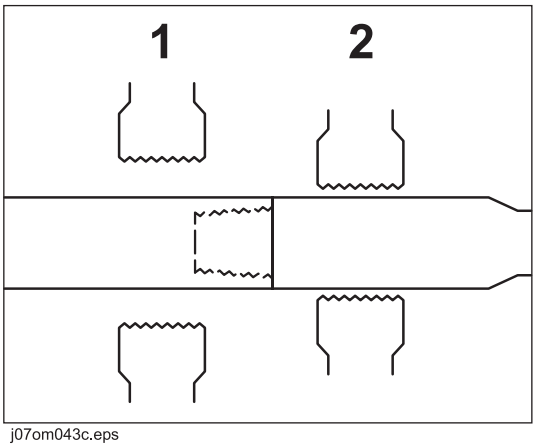
Carriage Movement	Rotation Direction	
forward	clockwise (makeup)	ic1102a.eps
reverse	counterclockwise (breakout)	ic1104a.eps

Clamp Pipe

DANGER Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE: Clamping anywhere else on the pipe will weaken the pipe. Pipe can later break, even when operating under normal loads.

Clamp on pipe when joint is centered between wrenches (1 and 2). Always clamp on the larger diameter areas on either side of the tool joint face.



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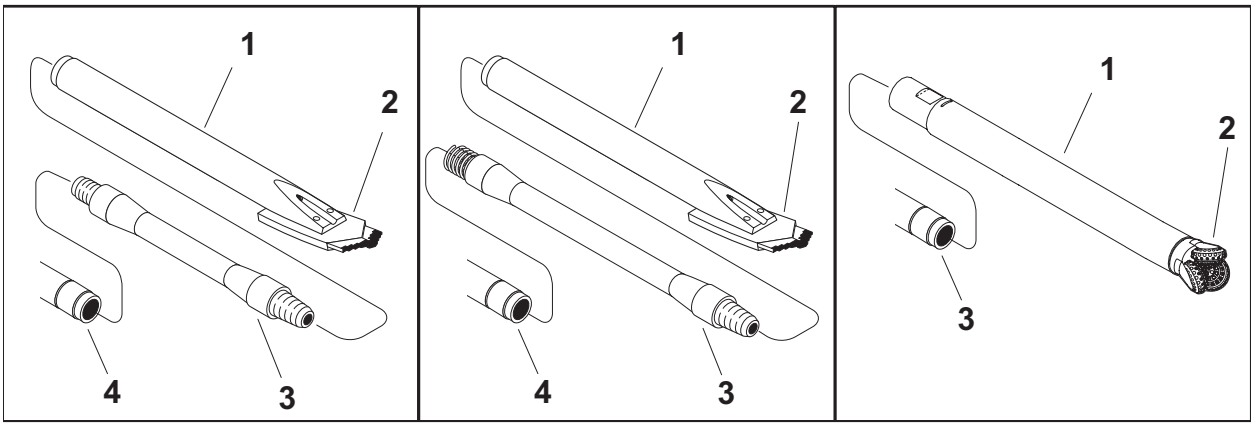
Assemble Drill String



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JT mode	AT dirt mode	AT mode
1. beacon housing 2. bit 3. transition sub 4. JT4020 Mach 1 drill pipe	1. beacon housing (p/n 368-822) 2. bit 3. transition sub (p/n 401-143) 4. JT4020 All Terrain drill pipe	1. Rockmaster tool 2. bit 3. JT4020 All Terrain drill pipe

IMPORTANT: If no part number is listed, contact your Ditch Witch dealer about available options.

Prepare Beacon Housing

1. Select nozzles (JT and AT dirt modes only) and bit.

   IMPORTANT: A variety of nozzles and bits are available to suit your particular job conditions. See "Downhole Tools" on page 134 for more information, or contact your Ditch Witch dealer.

2. Insert nozzle into beacon housing (JT and AT dirt modes only).
3. Attach bit to beacon housing.
4. Install beacon, following beacon instructions for:
   - battery replacement
   - beacon positioning
5. Install beacon housing lid. See "Beacon Housings" on page 135.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.

Attach Transition Sub

Use either machine torque or Hydratong wrenches to attach transition sub.

Machine Torque

1. Pull transition sub into front wrench.
2. Close wrench.
3. Lube joints.
4. Slowly make up joint.
5. Use full machine torque to tighten joint fully.

Hydratong

1. Lube joints with TJC.
2. Attach Hydratong to the joint in the join position and tighten joint. See "Hydratong Wrenches" on page 139.

Attach Beacon Housing

1. Attach downhole tool to transition sub and hand tighten.
2. Attach Hydratong to the joint in the join position and tighten joint. See "Hydratong Wrenches" on page 139.

Connect Drill Pipe

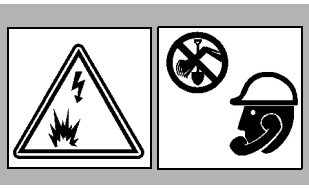
1. Start drilling unit engine.
2. Align transition sub in front wrench.
3. Clamp tool in front wrench. See "Clamp Pipe" on page 96.
4. Load pipe.
   - Make sure shuttle stop is positioned correctly. See "Check Shuttle Stop Position" on page 111.
   - Lubricate threads in front wrench.
   - Fill applicator at back of pipeloader.
   - Grip pipe.
   - Move pipe to spindle.
5. Connect pipe.
   - Move carriage forward until saver sub nears male pipe thread.
   - Continue to move carriage forward and rotate spindle until pipe screws into saver sub.
   - Relax grippers.
   - Move carriage forward until front end of pipe is aligned with transition sub male thread.
   - Use machine power to slowly rotate spindle and drill pipe onto transition sub male thread.
   - Raise pipe that is in pipe box.
   - Open grippers.
   - Move shuttle back against shuttle stop.
   - Lower pipe completely into shuttle.
6. Slowly tighten to full machine torque.
7. Disengage front wrench and move carriage back to top of frame.
8. Stop drilling unit engine.
9. Reinstall blocks on guides.

Drill First Pipe

DANGER Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE:

- Keep everyone at least 10' (3 m) away from turning drill string.
- Push rod or pipe slowly. Forcing can bend string. Do not use bent rod or pipe.



WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

JT Mode/AT Dirt Mode

1. Turn on drilling fluid.
2. Visually check for drilling fluid flow.
3. Turn drill bit to starting position. See "Prepare Entry Point" on page 75.
4. Slowly move carriage forward. Drill in 13' (4 m) before steering.
5. Monitor gauges.

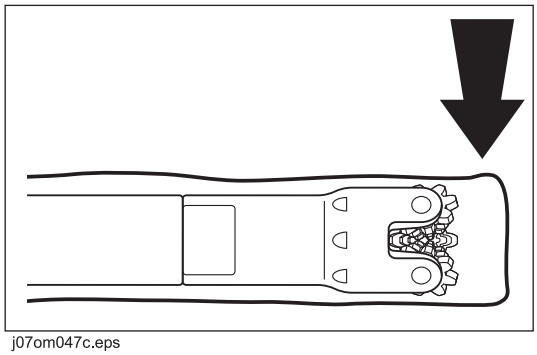
AT Mode

1. Turn on drilling fluid.
2. Visually check for drilling fluid flow.
3. Choose clock position and set spindle brake.
4. Rotate inner spindle clockwise.
5. Slowly move carriage forward. Drill first pipe as straight as possible.
6. Monitor gauges.
    - If inner rotation pressure approaches 1600 psi (110 bar), slow carriage travel.
    - If inner rotation stalls, stop carriage thrust. If inner rotation does not resume, pull pipe back.

Swab the Hole

IMPORTANT: Swab hole after each pipe is drilled to remove cuttings and keep the hole clear (AT Mode only). Some conditions may require more frequent swabbing.

1. Move carriage forward until wrench springs are fully compressed.
2. Move carriage to rear of drill frame with drilling fluid and inner rotation on.
3. Move carriage forward until carriage touches rear wrench to leave gap between end of bore and drill head (shown).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Enable Automated Pipeloader System

Add Pipe	Remove Pipe
1. Open front wrench and retract shuttles for add pipe function to work.	1. Open front wrench and retract shuttles for remove pipe function to work.
2. Press top of add pipe/manual/remove pipe switch. Green control cycle light will come on.	2. Press bottom of add pipe/manual/remove pipe switch. Green control cycle light will come on.
3. Grippers will open, pipe will be lowered, and then green control cycle light will flash.	3. Grippers will open, pipe will be lowered and lifted off shuttles, and then green control cycle light will flash.

IMPORTANT: If you leave the seat during an add or remove pipe cycle, turn automated pipeloader system off (switch to manual control) and then back to add pipe or remove pipe. If you leave the seat between add or remove pipe cycles, re-enabling system is not needed.

Add Pipe

1. Press top of drilling unit throttle switch until engine is at full throttle.
2. Enable automated pipeloader system (automated pipeloader control only). See "Enable Automated Pipeloader System" on page 101.
3. Break joint at saver sub.

Manual Pipeloader Controls	Automated Pipeloader Control
• Clamp pipe joint. See "Clamp Pipe" on page 96. • Locate drill head. • Engage front wrench until pipe is clamped and pressure develops. • Slowly move carriage back until movement stops. • Slowly rotate spindle counterclockwise. Carriage will move back as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame.	• Clamp pipe joint. See "Clamp Pipe" on page 96. • Locate drill head. • Engage front wrench until pipe is clamped and pressure develops. • Slowly move carriage back until movement stops. • Slowly rotate spindle counterclockwise. Carriage will move back as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame. • While carriage is moving, green control cycle light will come on. Grippers will grip, pipe will be lubed, and then green control cycle light will flash.

4. Load pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Make sure shuttle stop is properly positioned on pipeloader (see "Check Shuttle Stop Position" on page 111) and lift arms are completely lowered. • Close grippers. • Lube upper pipe threads. • Move pipe to spindle and lube lower threads. • Raise pipe in box.	• Make sure shuttle stop is properly positioned on pipeloader. See "Check Shuttle Stop Position" on page 111. • When carriage is moved to back of drill frame, press RESUME. Green control cycle light will come on. • Pipe will be moved to spindle, front threads will be lubed, pipe in box will be lifted, and then green control cycle light will flash.

5. Connect pipe to saver sub.

Manual Pipeloader Controls	Automated Pipeloader Control
IMPORTANT: Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints. • Move carriage forward until saver sub meets pipe. • Continue to slowly advance carriage and rotate spindle until pipe threads tighten. • Relax grippers.	**IMPORTANT:** Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints. • Move carriage forward until saver sub meets pipe. • Continue to slowly advance carriage and rotate spindle until pipe threads tighten. • Press RESUME. Green control cycle light will come on. • Grippers will relax and then green control cycle light will flash.

6. Connect new pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Slowly move carriage forward and rotate spindle until pipe threads tighten. • To fully torque joint, slowly rotate pipe until spindle stops turning. • Open wrench. • Open grippers fully. • Retract shuttles against shuttle stop. • Lower pipe lifters.	• Slowly move carriage forward and rotate spindle until pipe threads tighten. • To fully torque joint, slowly rotate pipe until spindle stops turning. • Open wrench. • Press RESUME. Green control cycle light will come on. • Grippers will open, shuttles will retract, pipe lifters will lower, and then green control cycle light will flash.

7. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.
8. Rotate spindle.
9. Slowly move carriage forward. Adjust rotation speed control according to bit size and soil conditions.
10. Engage and set cruise control as desired. See "Cruise Control" on page 151.
11. Monitor gauges.
12. Locate drill head with tracker at least every half-length of pipe.

Correct Direction

Correcting direction is a skill operators gain with experience and knowledge of equipment and soil conditions. These instructions cover only basic procedures. For information about specific equipment or jobsites, contact your Ditch Witch dealer.

To track progress and make corrections, one crew member locates the drill head and sends instructions to the operator. Corrections are made by tracking the drill head, comparing current position to bore plan, and steering drill head as needed.

Basic Rules

General

- Steering ability depends on soil condition; bit, drill head, and nozzle used; roll of drill head; and distance pushed without outer rotation.
- All corrections should be made as gradually as possible. See "Recommended Bend Limits" on page 71.
- Over correcting will cause "snaking." This can damage pipe and will make drilling and pullback more difficult. Begin to straighten out of each correction as early as possible.

JT Mode/AT Dirt Mode

- Do not push an entire piece of drill pipe into ground without rotation. This can exceed bend radius and cause pipe failure.

AT Mode

- Steering in rock is slower than steering in other soil conditions. Be patient.
- Inner shaft is rotating at all times when AT mode is selected and inner rotation switch is on.
- Engage spindle brake when making directional changes.
- Depth estimate and pitch accuracy improve if drill head is at 3 o'clock when reading is taken.
- Pull back 6" (152 mm) of pipe before checking pitch.

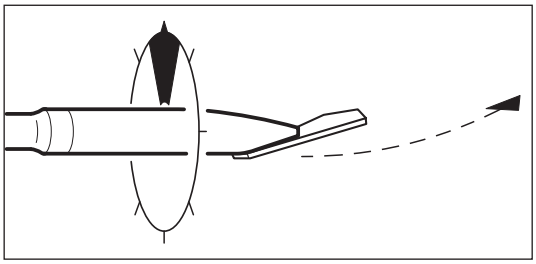
Procedure

1. Locate drill head. Take readings available with your beacon and locating equipment such as:
   - depth
   - pitch
   - left/right information
   - temperature
   - beacon roll
2. Compare position to bore plan. Determine direction drilling should go.
3. Position drill head.
4. Drill in pipe.

Drill Head Position

The drill head position is determined by reading beacon roll. Roll is displayed as a clock face position.

1. Read beacon roll.
2. Slowly rotate pipe until locator displays desired beacon roll.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To change direction:

JT mode/AT dirt mode	AT mode
1. Rotate pipe to clock position you intend to travel. 2. Push pipe into ground.	1. Rotate outer pipe to clock position you intend to travel. 2. Engage spindle brake. 3. Engage inner rotation and push pipe into ground.

To move forward without changing direction:

JT mode/AT dirt mode	AT mode
1. Rotate pipe. 2. Push pipe into ground.	1. Rotate outer pipe. 2. Engage inner rotation and push pipe into ground.

Record Bore Path

Locate drill head every half-length of pipe. As the job is completed, record the actual data for each drill pipe. List pitch and depth of each joint and a brief description of the procedure. In addition, draw a simple sketch of the site and record depth and rough location of pullback.

The Trac Management System Plus is also available for plotting and tracking your bore path. It utilizes the 750 Tracker, 750 Display, a tracking beacon, and special software. The display can store jobs in its memory or the system can be run in the field using a laptop computer equipped with the Windows® 95 or higher operating system. See your Ditch Witch dealer for details.

Surface Drill Head

⚠ DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

1. Guide drill head to target pit or up through surface. Make all bends gradual. See "Recommended Bend Limits" on page 71.
2. Clean area around exit point.
3. If using tracker control mode, tracker operator turns off tracker to disable drilling unit thrust/pullback and rotation hydraulics. Tracker operator waits for green light to enter pit and change tools.

   If not using tracker control mode, tracker operator signals to drilling unit operator to stop engine before changing downhole tools.
4. Turn fluid flow control to off position as soon as drill head emerges.
5. Clean drill head especially around threads.
6. Use Hydratong to remove drill head. Keep threads clean. See "Hydratong Wrenches" on page 139.

Assemble Backream String

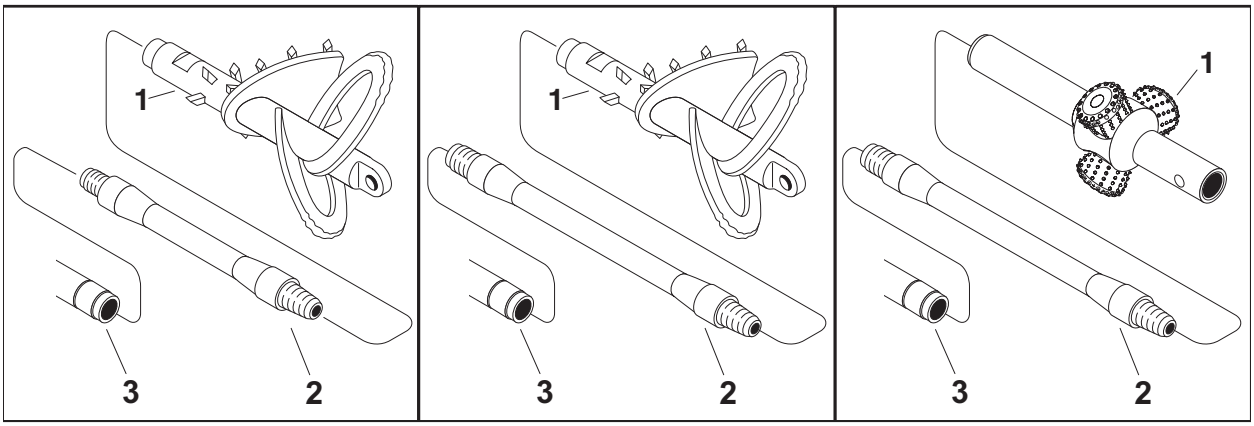
DANGER Turning shaft will kill you or crush arm or leg. Stay away.

NOTICE: Keep everyone away from material being installed.

DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

NOTICE: Continue to use strike system during backreaming.



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JT mode	AT dirt mode	AT mode
1. backreamer	1. backreamer	1. backreamer
2. transition sub	2. transition sub (p/n 400-685)	2. transition sub (p/n 400-685)
3. JT4020 Mach 1 drill pipe	3. JT4020 All Terrain drill pipe	3. JT4020 All Terrain drill pipe

IMPORTANT: If no part number is listed, contact your Ditch Witch dealer about available options.

1. Select backreaming devices. See "Backreamers" on page 136.
2. Determine fluid rate requirements and install appropriate nozzles to provide sufficient flow. See "Backream Fluid Requirements" on page 137 and "Nozzles" on page 134.
3. Attach backreamer to beacon housing if tracking backream.
4. Install beacon, following beacon instructions for:
   - battery replacement
   - beacon positioning
5. Install beacon housing lid. See "Beacon Housings" on page 135.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.
8. Use Hydratong wrenches to attach transition sub to drill pipe string. See "Hydratong Wrenches" on page 139.
9. Use Hydratong wrenches to attach backreamer/beacon housing assembly to transition sub. See "Hydratong Wrenches" on page 139.
10. Attach additional pullback devices or product to end of backreamer/beacon housing assembly.

Remove Pipe

1. Enable automated pipeloader system (automated pipeloader control only). See "Enable Automated Pipeloader System" on page 101.
2. Stop carriage when alignment pin becomes visible behind rear wrench.
3. Clamp pipes. See "Clamp Pipe" on page 96.
4. Break front joint:
   - Turn rear wrench counterclockwise to break joint.
   - Disengage rear wrench and rotate wrench clockwise.
5. Grip pipe:

Manual Pipeloader Controls	Automated Pipeloader Control
• Open grippers. • Lift pipe off shuttles. • Extend shuttles to spindle position. • Close grippers. Leave grippers loose enough to allow pipe to rotate. • Lower lifters.	• Press RESUME. Green control cycle light will come on. • Shuttles will extend, grippers will grip fully and relax open, pipe lifters will lower, and then green control cycle light will flash.

6. Separate front joint:
   - Slowly rotate spindle counterclockwise and move carriage back to separate pipe.
   - Continue to move carriage back until pipe is properly positioned in rear wrench.

7. Break rear joint:

Manual Pipeloader Controls	Automated Pipeloader Control
• Engage rear wrench. • Slowly rotate spindle counterclockwise and move carriage back until joint is loosened. **Do not** fully separate joint. • Disengage rear wrench. • Move carriage back until front end of pipe is aligned with front end of pipe box or alignment pin is even with tab on frame. • Close grippers. • Rotate spindle counterclockwise and move carriage back until saver sub is separated from pipe. • Move carriage to back of frame.	• Engage rear wrench. • Slowly rotate spindle counterclockwise and move carriage back until joint is loosened. **Do not** fully separate joint. • Disengage rear wrench. • Move carriage back until front end of pipe is aligned with front end of pipe box or alignment pin is even with tab on frame. • Press RESUME. Green control cycle light will come on. • Grippers will close and then green control cycle light will flash. • Rotate spindle counterclockwise and move carriage back until saver sub is separated from pipe. • Move carriage to back of frame.

8. Ensure shuttle stop is positioned correctly. See "Check Shuttle Stop Position" on page 111.
9. Load pipe into pipe box:

Manual Pipeloader Controls	Automated Pipeloader Control
• Move shuttle under pipe box to shuttle stop. • Release grippers and raise lift arms to place pipe in box. • Lube front threads.	• Press RESUME. Green control cycle light will come on. • Shuttles will retract under edge of pipe box and then green control cycle light will flash. • Move carriage forward until it clears end of pipe box. Green control cycle light will come on. • Shuttles will retract to shuttle stop, front threads will be lubed, grippers will release pipe, pipe lifters will raise until pipe is off shuttles, and then green control cycle light will flash.

10. Attach saver sub to next pipe:
    - Move carriage forward until saver sub touches pipe.
    - Rotate spindle and move carriage forward just enough to allow saver sub to connect to pipe.
    - Slowly tighten joint to full machine torque.
11. Disengage front wrench to release pipe.

Remove Pullback Device

The pullback device can be removed when the last pipe is on the frame. It can also be removed when a target pit along the bore path has been reached. Remaining pipe is then pulled back and removed.

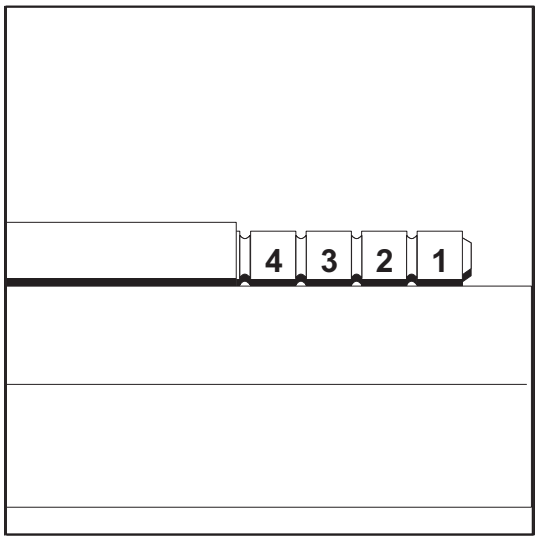
DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

1. Press bottom of drilling unit throttle switch until engine is at low throttle.
2. Turn off drilling fluid.
3. Turn off drilling unit engine.
4. Clean pullback device.
5. Use Hydratong wrenches to remove pullback device. See "Hydratong Wrenches" on page 139.

Check Shuttle Stop Position

Look at shuttle stop position indicator to verify which row of pipe shuttles will stop under. Row one is closest to operator. For example, row four (farthest from operator) is shown. See "Shuttle stop control" on page 25.

IMPORTANT: Stopping shuttles under the wrong row can result in drill pipes falling out of pipe box.



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Systems and Equipment

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Anchor System

WARNING Crushing weight. If load falls or moves, it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

- Drive anchors properly before drilling.
- Wear high-top protective boots with legs of pants completely tucked inside.
- Wear protective gloves.
- If you are not driving two anchors to full depth, drive optional ground rod into soil away from drilling unit.

DANGER Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE: Do not replace anchor collar bolt with one longer than original. Clothing could catch on turning shaft.

Select Anchor

Many anchor types are available. Choose the correct anchor type based on jobsite conditions.

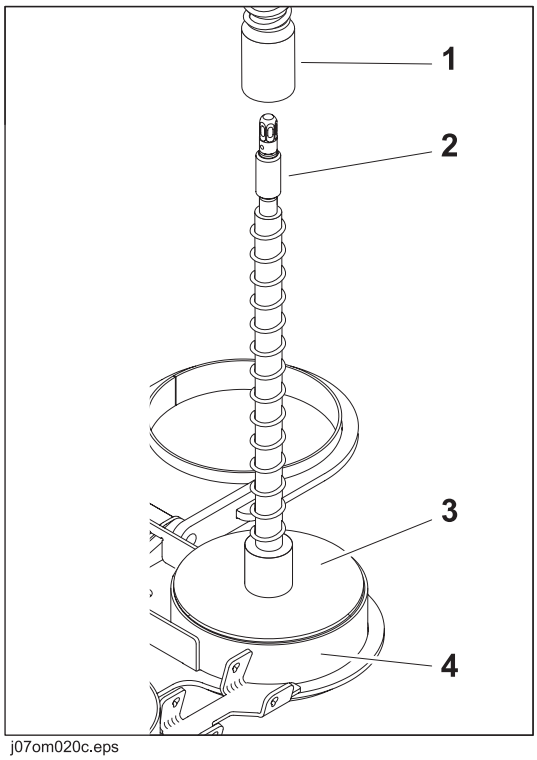
Anchor type	Situation used
3.5" cap bit	hard/soft rock, asphalt, concrete, cobble
auger bit	soft soil to hard soil, soft rock; available in different sizes

Attach Anchor to Anchor Driver

IMPORTANT: Use tall caps (p/n 308-903) for front anchors and short caps (p/n 308-750) for side anchors.

1. Raise anchor driver to top of anchor frame.
2. Pull collar (1) up.
3. Position lower part of anchor and centering cap (3) inside anchor base (4).
4. Guide top of anchor (2) into collar. Raise and turn anchor slightly until collar clicks and locks onto anchor shaft.

IMPORTANT: If collar will not lock, remove anchor shaft and push plug inside collar to release ball.



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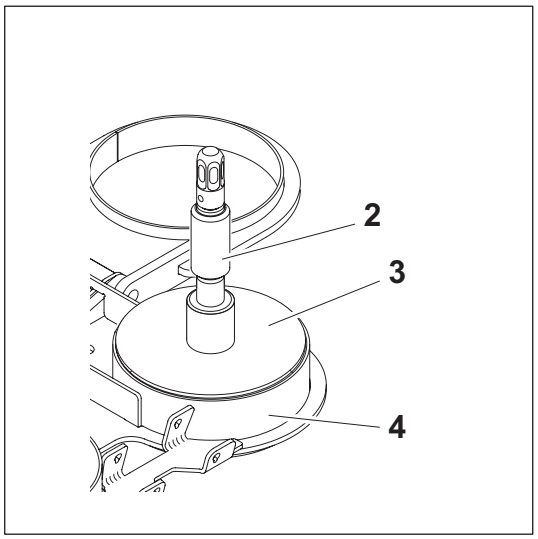
Drive Anchors

1. Raise anchor shaft (2) to top of anchor frame.
2. Use anchor rotation and thrust controls to drive anchor into ground.
3. Anchor is set when centering cap (3) rests firmly on anchor base (4).
4. Repeat process for other anchor.

NOTICE: Failure to disconnect anchor drivers from anchor shafts will lead to anchor driver motor failure.



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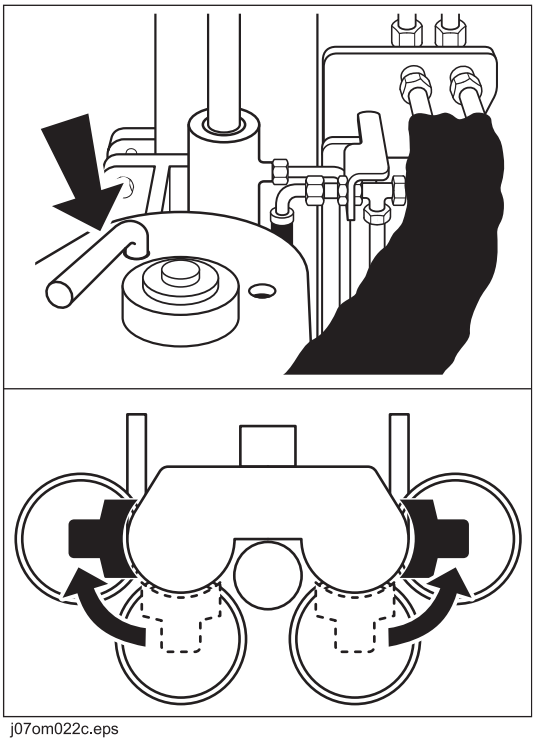
Drive Additional/Side Anchors

1. Raise collar to disconnect anchor shaft from anchor driver.
2. Raise anchor driver to top of anchor frame.
3. Remove spring clip from pin (shown) and remove pin.
4. Swing anchor driver to outer position.
5. Place pin in second hole and replace spring clip.
6. Attach anchor to anchor driver and repeat steps 2 and 3.
7. Disconnect anchors from anchor drivers before drilling.

NOTICE: Failure to disconnect anchor drivers from anchor shafts will lead to anchor driver motor failure.



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Remove Anchors

1. Use anchor rotation and thrust controls to slowly remove anchor shaft from ground.
2. Repeat process for other anchor(s).

Electric Strike System

Any time you drill in an electric jobsite, electric strike system must be properly set up, tested, and used. You must wear protective boots and gloves meeting the following standards:

- Boots must have high tops and meet the electric hazard protection requirements of ANSI Z-41, 1991, when tested at 14,000V. Tuck legs of pants completely inside boots.
- Gloves must have 17,000 AC maximum use voltage, according to ASTM specification D120-87.

If working around higher voltage, use gloves and boots with appropriately higher ratings.

NOTICE: The strike system does not prevent electric strikes or detect strikes before they occur. **If alarms are activated, a strike has already occurred** and equipment is electrified.

Read and follow "Electric Jobsite Precautions" on page 69. Review safety procedures before each job.

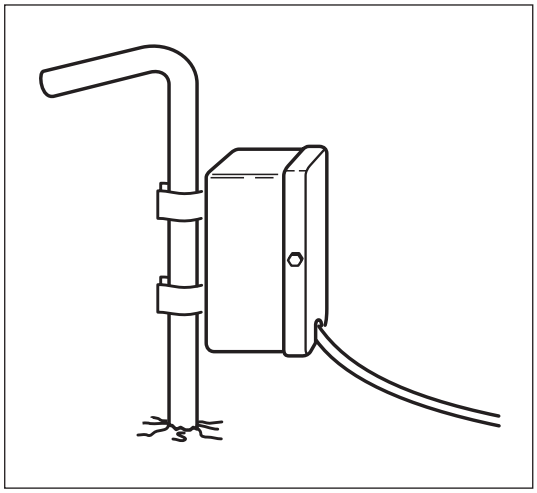
FCC Statement

The Electric Strike System has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, can cause harmful interference to radio communications. Operation of this equipment in a residential area could cause harmful interference which the user will be required to correct at his own expense.

Changes or modifications not expressly approved in writing by The Charles Machine Works, Inc. may void the user's authority to operate this equipment.

Assemble Voltage Detector

1. Drive voltage stake into ground at least 6' (2 m) away from any part of system.
2. Clip voltage limiter to voltage stake.



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Test Strike System

If system fails any part of this test, see "Troubleshoot Strike System" on the following page. Do not drill until test is completed successfully.

1. Turn on drilling unit.
2. ESID control module will perform internal tests which check everything but alarms and strobe.
3. If green OK indicator and electrical power supply indicator lights remain on, press self test button to perform total test of strike system. During this test:
   - All lights should glow.
   - Alphanumeric readout should display numbers.
   - Alarms and strobes on all connected units should sound.
4. If this test is successful, OK indicator and electrical power supply indicator lights will remain on.
5. Use Electric Strike Simulator to test voltage and current sensors. See page 123.

Troubleshoot Strike System

When strike system detects a problem, an error code will be displayed. Anytime this happens, press self test button to retest. If error code is still displayed and does not appear in this chart, have control module checked or replaced.

Other problem situations and their possible causes and solutions are listed in the chart below.

Problem	Possible cause	Possible solution
No lights or readings showing after drilling unit key has been on at least one minute	Problems in startup	Push self test button. If problem goes away, retest strike system
	No power to strike system control module	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
		Check that cable from drilling unit carries more than 10V
	Defective control module	Have control module checked or replaced
Screen is blank	Strike system is not getting adequate power from drilling unit	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
		Check that harness from drilling unit carries more than 10V
	Defective control module	Have control module checked or replaced
OK indicator is on, but electrical power supply indicator is off	Strike system is not getting adequate power from drilling unit	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
		Check that harness from drilling unit carries more than 10V
	Defective control module	Have control module checked or replaced
Electrical power supply indicator is on, but OK indicator is off	Problem detected during test	Check for error code and have control module checked or replaced
	Defective control module	Have control module checked or replaced

Problem	Possible cause	Possible solution
Strobe light on drilling unit does not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective strobe light	1. Disconnect strobe and connect to external 12V power source. 2. If strobe does not work, replace it.
	Defective control module	Have control module checked or replaced
Alarm on drilling unit does not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective alarm	1. Disconnect strobe and connect to external 12V power source. 2. If strobe does not work, replace it.
	Defective control module	Have control module checked or replaced
Strobe light and alarm on drilling unit do not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective control module	Have control module checked or replaced
EC2 code displays and current problem indicator is on	Improper connections with control module	Check cable connections on control module and current transformer
	Defective current transformer	1. Disconnect current transformer. 2. Check for 20-40 ohms from pin 1 to pin 4, 20-40 ohms from pin 1 to pin 2, and less than 1 ohm from pin 2 to pin 4.
	Defective current transformer cable	1. Disconnect cable from transformer and control module. 2. Check continuity of cable. 3. If continuity is zero or cable is damaged, replace.
	Defective control module	Have control module checked or replaced
EV2 code displays and voltage problem indicator is on	Improper connections with control module	Check cable connection on control module
	Defective voltage limiter	Have voltage limiter checked or replaced
	Defective control module	Have control module checked or replaced

ESID Diagnostic Codes

Code	Definition	Action
DC 10	strobe output error	• verify that strobe light is properly connected to machine harness • check for broken or shorted wires in the harness • perform a self test of the ESID module; during self test, check for 12V at pin 5 (GRN/YEL) of ESID power connection and at BLK/RED ground circuit
DC 11	horn output error	• verify that horn is properly connected to machine harness • check for broken or shorted wires in the harness • perform a self test of the ESID module; during self test, check for 12V at pin 1 (BRN) of ESID power connection and at BLK/RED ground circuit
DC 12	12V DC battery power error	check battery charge
DC 15	strike voltage input error	• verify that voltage limiter is properly connected to ESID module • check for broken or shorted wires in the voltage limiter • perform a self test of the ESID module; if code does not clear, contact Trenchless Product Support
DC 16	strike current coil input error	• verify that current coil is properly connected to the current coil and to the ESID module • check for broken or shorted wires in the cable • perform a self test of the ESID module; if code does not clear, contact Trenchless Product Support
DC 17	self test AC voltage input error	verify that voltage limiter cable is properly connected
DC 18	self test AC current input error	verify that current coil and cable are properly connected
DC 19	self test DC voltage input error	verify that voltage limiter cable is properly connected
DC 20	self test DC current input error	verify that voltage limiter cable is properly connected
DC 21	voltage limiter not properly grounded	• verify that voltage limiter is connected securely to voltage stake • verify that stake is fully in the ground or properly grounded to machine frame

Use Electric Strike Simulator

Use the Electric Strike Simulator (p/n 259-506) to test voltage and current sensors on ESID. If readings are less than indicated here, replace 9V battery in simulator and retest.

Current Test

To test for current at normal levels:

1. Thread one lead wire through current transformer.
2. Clip ends of lead wires together to make one loop.
3. Move simulator switch to "current" and press test button.
4. Watch screen and lights above display on strike system.
   - Three or four lights should turn on.
   - Current "A" should show 30-50% in display.

To test for current at strike levels:

1. Put two or three loops through current transformer.
2. Follow steps above to test.
3. Display should show the following:
   - All lights should turn on.
   - Alarm and strobe should turn on.

   With two loops,
   - Current "A" should be 80-110%.
   - Strike indication might go on and off.

   With three loops,
   - Current should be 130-160%.
   - Strike indication should be continuous.

Voltage Test

1. Place voltage limiter on something insulated from ground and drilling unit (such as dry board or tire), but near frame of drilling unit.
2. Clip one lead to frame.
3. Clip other lead to one voltage limiter mount.
4. Move simulator switch to "voltage" and press test button.
5. Watch screen and lights above display on strike system.
    - All lights should turn on.
    - Alarm and strobe should turn on.
    - Voltage "V" should show 90-110%.

It is normal for simulator voltage levels to drift below strike level. When this happens, light in triangle should go off and alarm and strobe should stop working. If the level drifts above strike level again, light, alarm, and strobe should be turned on again.

ESID Diagnostic Codes

Code	Definition	Action
DC 10	strobe output error	• verify that strobe light is properly connected to machine harness • check for broken or shorted wires in the harness • perform a self test of the ESID module; during self test, check for 12V at pin 5 (GRN/YEL) of ESID power connection and at BLK/RED ground circuit
DC 11	horn output error	• verify that horn is properly connected to machine harness • check for broken or shorted wires in the harness • perform a self test of the ESID module; during self test, check for 12V at pin 1 (BRN) of ESID power connection and at BLK/RED ground circuit
DC 12	12V DC battery power error	check battery charge

Code	Definition	Action
DC 15	strike voltage input error	• verify that voltage limiter is properly connected to ESID module • check for broken or shorted wires in the voltage limiter • perform a self test of the ESID module; if code does not clear, contact Trenchless Product Support
DC 16	strike current coil input error	• verify that current coil is properly connected to the current coil and to the ESID module • check for broken or shorted wires in the cable • perform a self test of the ESID module; if code does not clear, contact Trenchless Product Support
DC 17	self test AC voltage input error	verify that voltage limiter cable is properly connected
DC 18	self test AC current input error	verify that current coil and cable are properly connected
DC 19	self test DC voltage input error	verify that voltage limiter cable is properly connected
DC 20	self test DC current input error	verify that voltage limiter cable is properly connected
DC 21	voltage limiter not properly grounded	• verify that voltage limiter is connected securely to voltage stake • verify that stake is fully in the ground or properly grounded to machine frame

Drilling Fluid

For productive drilling and equipment protections, use these recommended Baroid® products, available from your Ditch Witch dealer.

- Soda ash
- Quik-Gel™ dry powder bentonite (p/n 259-804)
- E-Z Mud™ liquid polymer (p/n 259-805)
- Liqui-Trol™ liquid polymer suspension (p/n 259-808)
- Quik-Trol™ dry powder polymer (p/n 259-809)
- Bore-Gel™ drilling fluid (p/n 259-807)
- Con-Det™ water-soluble cleaning solution (p/n 259-810)

Guidelines

Match drilling fluid to soil type. This chart is meant as a guideline only. See your local Ditch Witch dealer for soil conditions and drilling fluid recommendations for your area. Also see our interactive Drilling Fluid Formulator at **www.ditchwitch.com**.

Soil type	Drilling fluid recommendation
smooth, flowing sand	bentonite or Bore-Gel + medium chain polymer
coarse sand or light soil	bentonite or Bore-Gel
heavy clay	long chain polymer + Con-Det
swelling clay	long chain polymer + Con-Det
rock	Bore-Gel

Polymer

This drilling fluid additive provides excellent lubrication and increases viscosity in average soils and heavy clay. In swelling clay, polymer can reduce swelling that traps pipe in the bore.

There are two types of polymer:

- long chain such as Baroid EZ-Mud
- medium chain such as Baroid Quik-Trol

Bentonite

Bentonite is a dry powder. When properly mixed with water, it forms a thin cake on bore walls, lubricating the bore, keeping it open, and holding fluid in the bore.

Some things to remember when mixing bentonite:

- Use clean water free of salt, calcium, or excessive chlorine.
- Use water with pH level between 9 and 10.
- Use water with hardness of less than 120 ppm.
- Do not use bentonite containing sand.
- Mix bentonite thoroughly or it will settle in tank.
- Do not mix bentonite to a funnel viscosity of over 50.

For information on measuring funnel viscosity, see "Funnel Viscosity" on page 130.

Mixtures

Bentonite does not mix well in water containing polymer. To use both, mix bentonite first, then add polymer. When adding other products follow the order listed below.

NOTICE:

- If chemicals are added in the wrong order, they will not mix properly and will form clumps.
- If tank contains bentonite/polymer mix and more drilling fluid is needed, completely empty tank and start with fresh water before mixing another batch.

General mixing order:

1. Soda ash
2. Bentonite
3. Polymer
4. Con-Det

Bore-Gel contains premixed bentonite, polymer, and soda ash. Use approximately 15 lb/100 gal (7 kg/380 L) in normal drilling conditions, up to 45 lb/100 gal (21 kg/380 L) in sand or gravel and up to 50 lb/100 gal (23 kg/380 L) in rock.

Basic Fluid Recipes

Soil type	Mixture/100 gal (378 L) of water	Notes
fine sand	35 lb (16 kg) Bore-Gel	
coarse sand	35 lb (16 kg) Bore-Gel .5 lb (225 g) No-Sag	Add .5 lb (225 g) of Quik-Trol for additional filtrate control
fine sand below water table	40 lb (18 kg) Bore-Gel .75 lb (340 g) Quik-Trol	Add .5 - 1 gal (2-4 L) of Dinomul in high torque situations
coarse sand below water table	40 lb (18 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 - 1 gal (2-4 L) of Dinomul in high torque situations
gravel	50 lb (23 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 lb (225 g) of Barolift to reduce loss of returns
cobble	50 lb (23 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 lb (225 g) of Barolift to reduce loss of returns
sand, gravel, clay or shale	35 - 40 lb (16-18 kg) Bore-Gel .5 pt (235 mL) EZ-Mud .5 gal (2 L) Con-Det	Vary mixture according to percentage of sand and clay
clay	.5 lb (225 g) Poly Bore .5 gal (2 L) Con-Det	Flow rate should be 3-5 parts fluid to 1 part soil. May use .25 - .5 gal (1-2 L) of Penetrol instead of Con-Det
swelling/sticky clay	.75 - 1 lb (340-450 g) Poly Bore .5 - 1 gal (2-4 L) Con-Det	Flow rate should be 3-5 parts fluid to 1 part soil. May use .25 - .5 gal (1-2 L) of Penetrol instead of Con-Det
solid rock (shale)	40 lb (18 kg) Bore-Gel	Use .5 pt (235 mL) of No Sag for large diameter or longer bores
solid rock (other than shale)	40 - 50 lb (18-23 kg) Bore-Gel	Use .5 pt (235 mL) of EZ-Mud in reactive shales
rock/clay mixture	40 - 50 lb (18-23 kg) Bore-Gel .5 pt (235 mL) EZ-Mud	
rock/sand mixture	40 - 50 lb (18-23 kg) Bore-Gel	Use .5 pt (235 mL) of No Sag for large diameter or longer bores
fractured rock	50 lb (23 kg) Bore-Gel .5 - 1lb (225-450 g) No-Sag	Use .5 lb (225 g) of Barolift to reduce fluid loss to formation

Drilling Fluid Requirements

1. Determine drilling conditions and choose appropriate drilling fluid mix.
2. Estimate amount of supplies needed and check availability.
   - Drilling fluid
   - Water supply. If more water than can be carried with the unit will be needed, arrange to transport additional water.
   - Bentonite and/or polymer
3. Check water quality.
   - Use meter or pH test strips to test pH of water. If pH is below 9.0, add 1 cup (.25 L) soda ash per tank. Test and repeat until pH is between 9 and 10.
   - Check water hardness using hardness test strips. Treat with soda ash if hardness exceeds 125 ppm.

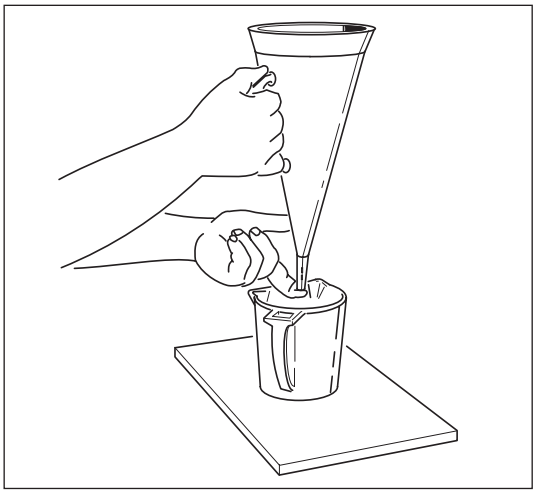
Funnel Viscosity

Viscosity is the measure of internal resistance of a fluid to flow; the greater the resistance, the higher the viscosity. Viscosity of drilling fluids must be controlled.

To determine viscosity, you will need a Marsh funnel (p/n 259-267) and a measuring cup, available from your Ditch Witch dealer.

IMPORTANT: Make sure Marsh funnel is clean and free of obstruction and that you have a stopwatch available for timing the viscosity.

1. Using wash hose and a clean container, take a fresh sample of drilling fluid. The sample must be at least 1.5 qt (1.4 L).
2. With finger over bottom of funnel, fill with fluid from the container through the screen until fluid reaches the bottom of the screen.
3. Move funnel over 1 qt (.95 L) container.
4. Remove finger from bottom of funnel and use the stopwatch to count the number of seconds it takes for 1 qt (.95 L) of fluid to pass through the funnel. The number of seconds is the viscosity.
5. Thoroughly rinse measuring cup and Marsh funnel.



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Tracker Control

Overview

WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

This mode allows the 750/752 Tracker operator to disable hydraulic power to drilling unit thrust and rotation.

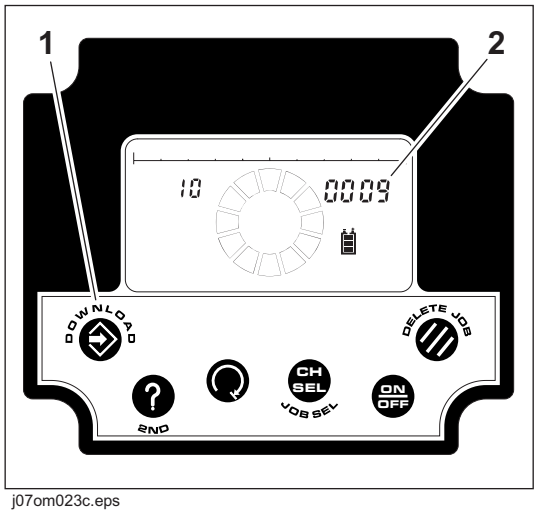
NOTICE: This mode does not disable thrust and rotation immediately. Functions are disabled within 16 seconds.

Use tracker control any time you change downhole tools or during other times when the drill string is exposed. Tracker control works by stopping communication between the tracker and the display. When this happens, the green tracker control light on the drilling unit comes on and thrust and rotation are disabled.

Operation

Enable Thrust and Rotation

1. Start drilling unit.
2. Turn off 750/752 Display.
3. Press and hold DOWNLOAD (1) while turning on 750/752 Display until a four-digit code (2) appears.



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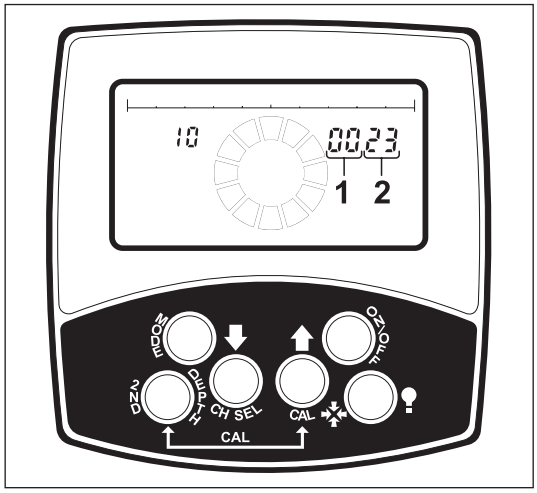
4. Turn on 750/752 Tracker and check four-digit code.

   If codes on tracker and display match, thrust and rotation hydraulics on the drilling unit are enabled.

   If codes on tracker and display do not match, adjust tracker code:

   - Press and hold fore/aft/left/right button while making the following adjustments.
   - Use ON/OFF to advance first two digits (1). Use DEPTH to lower first two digits.
   - Use up arrow to advance last two digits (2). Use down arrow to lower last two digits.
   - Press and hold each button to advance or lower value quickly.
   - To start sending code from the tracker to the display, press and hold fore/aft/left/right button and press MODE. Thrust and rotation hydraulics on the drilling unit are now enabled.



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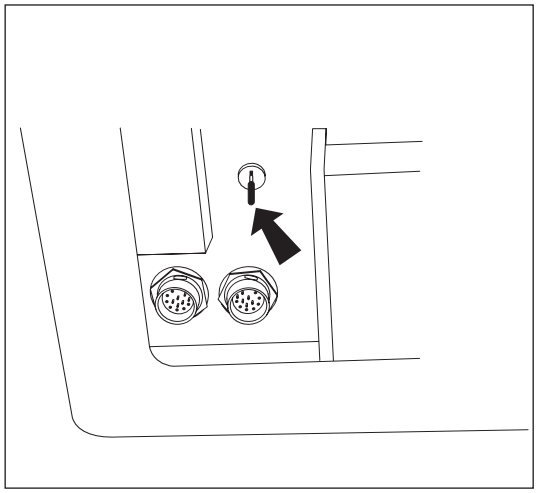
Troubleshooting Tip: If thrust and rotation are not enabled:

- Check whether the green tracker control light located on drilling unit anchoring console is on. If it is, communication has probably stopped between tracker and display, or tracker is set to incorrect code.
- If communication cannot be restored, install tracker control key (shown) in drilling unit. Green tracker control light located on anchoring console will go off. Thrust and rotation will function.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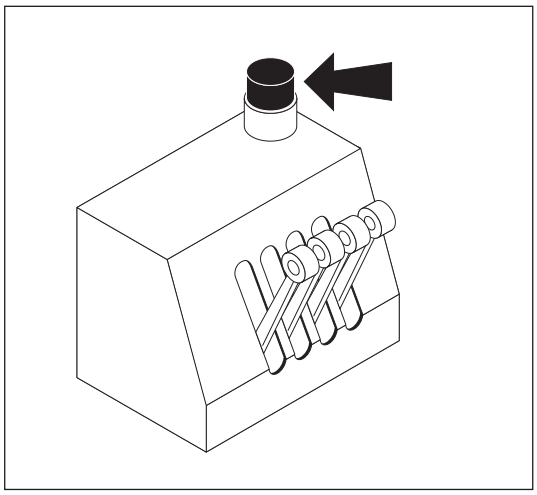
5. Remove tracker control key (shown) from drilling unit outer right console. Keep in tracker operator's possession.
6. Drill and track bore.

Disable Thrust and Rotation

1. When drill head enters target pit or exits the ground, turn off tracker.

   After 8-16 seconds, green tracker control light (shown), located on drilling unit anchoring console, will come on. Hydraulic power to thrust and rotation will be disabled.



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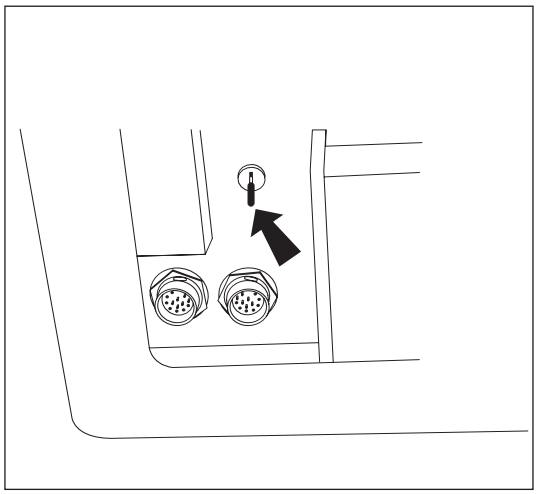
IMPORTANT: Tracker operator cannot disable thrust and rotation from tracker if tracker control key (shown) is installed in drilling unit and turned to the disable position. See "Tracker control key" on page 42 for more information.



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NOTICE: If you are not using tracker control, turn off drilling unit before changing downhole tools.

2. Change downhole tools.
3. **If you are tracking backreamer's path**, turn on tracker and enable code transmission. After 8-16 seconds, green tracker control light on drilling unit anchoring console will go off and thrust and rotation will function.

   If you are not tracking backreamer's path, install tracker control key (shown) on drilling unit. Green tracker control light on drilling unit anchoring console will go off and thrust and rotation will function.

Downhole Tools

Nozzles

Nozzles control fluid flow from the pipe to the bore. Select nozzles that will supply **at least** the amount of fluid per minute needed for the flow and pressure you will be using. A nozzle that will supply more fluid per minute is recommended. See your Ditch Witch dealer for nozzle recommendations.

Bits

Selection

These charts are meant as a guideline only. No one bit works well in all conditions. See your Ditch Witch dealer for soil conditions and bit recommendations for your area. Also see our interactive Downhole Tool Selector at **www.ditchwitch.com**.

- 1 = best
- 2 = good
- 3 = fair
- 4 = not recommended

Bit	Sandy Soil	Soft Soil	Medium Soil	Hard Soil	Rocky Soil	Soft Rock	Hard Rock
Sand bit	1	2	4	4	4	4	4
Durabit	2	2	1	1	4	4	4
Tuff bit	2	1	1	1	2	3	4
Steep Taper Tuff bit	4	3	2	1	1	2	4
Barracuda bit	2	1	1	2	3	4	4
Steep Taper bit	4	3	2	1	1	2	4
Hard Surface bit	2	1	2	3	4	4	4
Glacier bit	4	4	4	3	1	2	4
Rhino bit	4	4	3	3	1	1	3
Jetting assembly	4	4	3	2	1	2	3
Rockmaster	4	4	3	2	1	1	1
Talon Rock bit	4	3	2	1	1	1	4

Soil	Description
sandy soil	sugar sand, blow sand, or other soils where sand is the predominant component
soft soil	sandy loam
medium soil	loams, loamy clays
hard soil	packed clays, gumbo, all compacted soils
rocky soil	chunk rock, glacial till, cobble, rip rap, gravel
soft rock	soft limestone, sandstone, shale, coral, caliche
hard rock	granite, schist, marble, hard limestone

Installation

Remove all paint from mating surfaces before attaching any bit to housing. Install screws (p/n 107-284) and torque bolts to 580 ft•lb (800 N•m).

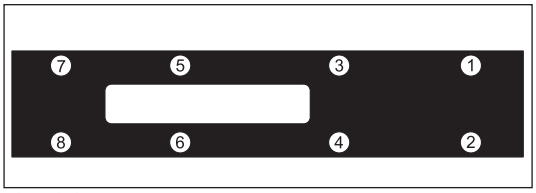
Beacon Housings

Beacon Installation

To ensure beacon is installed correctly in rock housing, place battery end of beacon away from bit end of housing.

Lid Installation

1. Clean all threads, bolt holes and mating surfaces.
2. Follow torque sequence (shown).
3. Use removable thread locker (Loctite® or equivalent), if desired.
4. Torque bolts to 60-70 ft•lb (81-95 N•m).
5. Repeat torque sequence.



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Backreamers

A backreamer enlarges the hole as pipe is pulled back through the bore. No one backreamer works well in all conditions. These charts are meant as a guideline only. See your local Ditch Witch dealer for soil conditions and backreamer recommendations for your area. Also see our interactive Downhole Tool Selector at **www.ditchwitch.com**.

- 1 = best
- 2 = good
- 3 = fair
- 4 = not recommended

Backreamer	Sandy Soil	Soft Soil	Medium Soil	Hard Soil	Rocky Soil	Soft Rock	Hard Rock
Beavertail	3	1	1	1	3	4	4
Three Wing	4	3	3	2	1	1	4
Water Wing	4	3	2	1	2	2	4
Compact Fluted	1	1	2	2	2	3	4
Kodiak	4	3	3	2	1	2	4
Rhino Rock	4	4	4	4	3	2	1
Rockmaster	4	4	4	4	3	1	1
Compaction Cone	1	2	3	4	4	4	4
HC Hard Condition	4	3	2	1	1	4	4
ST Saw Tooth	2	2	1	2	2	3	4
MX Mixer	2	2	3	4	4	4	4
CT Cutter	3	2	1	2	3	4	4
EX Expander	1	2	3	4	4	4	4
Fluted Cone	1	1	2	2	2	3	4

IMPORTANT: For soil definitions, see the chart on the previous page.

Backream Fluid Requirements

Backreaming is only successful when enough fluid reaches the bore. The amount of fluid needed depends on size of bore and soil condition.

Follow these steps to find the **minimum** amount of fluid needed in perfect conditions.

IMPORTANT: Use more fluid than recommended or the backream might be dry and unsuccessful.

Instructions	Example
1. Find amount of fluid needed for your size of backreamer. See the table on the next page.	**U.S.** A 6-in backreamer requires at least 1.47 gal/ft.
	Metric A 152-mm backreamer requires at least 18.24 L/m.
2. Multiply this number by distance per minute you plan to backream. The answer is an estimate of amount of fluid you will need for each minute of backreaming.	**U.S.** 1.5 gal x 2 ft/min = 3 gal for each minute of backreaming.
	Metric 18 L x .5 m/min = 9 L for each minute of backreaming

IMPORTANT: After you have determined how much fluid you will need, see your Ditch Witch dealer for nozzle recommendations.

Backream Fluid Requirements

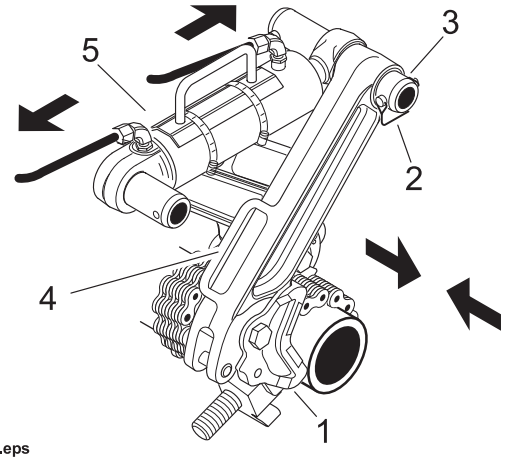
Backreamer/product diameter		Gal/ft	L/m	Backreamer/product diameter		Gal/ft	L/m
.5 in	13 mm	0.01	0.13	13.5 in	343 mm	7.44	92.35
1 in	25 mm	0.04	0.51	14 in	356 mm	8.00	99.31
1.5 in	38 mm	0.09	1.14	14.5 in	368 mm	8.58	106.54
2 in	51 mm	0.16	2.03	15 in	381 mm	9.18	114.01
2.5 in	64 mm	0.25	3.17	15.5 in	394 mm	9.80	121.74
3 in	76 mm	0.37	4.56	16 in	406 mm	10.44	129.72
3.5 in	89 mm	0.5	6.21	16.5 in	419 mm	11.11	137.95
4 in	102 mm	0.65	8.11	17 in	432 mm	11.79	146.44
4.5 in	114 mm	0.83	10.26	17.5 in	445 mm	12.49	155.18
5 in	127 mm	1.02	12.67	18 in	457 mm	13.22	164.17
5.5 in	139 mm	1.23	15.33	18.5 in	470 mm	13.96	173.42
6 in	152 mm	1.47	18.24	19 in	483 mm	14.73	182.92
6.5 in	165 mm	1.72	21.41	19.5 in	495 mm	15.51	192.68
7 in	178 mm	2.00	24.83	20 in	508 mm	16.32	202.68
7.5 in	190 mm	2.29	28.50	20.5 in	521 mm	17.15	212.94
8 in	203 mm	2.61	32.43	21 in	533 mm	17.99	223.46
8.5 in	216 mm	2.95	36.61	21.5 in	546 mm	18.86	234.23
9 in	229 mm	3.30	41.04	22 in	559 mm	19.75	245.25
9.5 in	241 mm	3.68	45.73	22.5 in	572 mm	20.65	256.52
10 in	254 mm	4.08	50.67	23 in	584 mm	21.58	268.05
10.5 in	267 mm	4.50	55.86	23.5 in	597 mm	22.53	279.83
11 in	289 mm	4.94	61.31	24 in	610 mm	23.50	291.86
11.5 in	292 mm	5.40	67.01	24.5 in	622 mm	24.49	304.15
12 in	305 mm	5.88	72.97	25 in	635 mm	25.50	316.69
12.5 in	318 mm	6.37	79.17	25.5 in	648 mm	26.53	329.49
13 in	330 mm	6.90	85.63	26 in	660 mm	27.58	342.53

Hydratong Wrenches

To attach or remove downhole tools, use the Hydratong wrenches to join or break the joint.

⚠ DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

1. To join, apply TJC to threads and hand tighten joint.
2. Attach Hydratong in either the join or break position.



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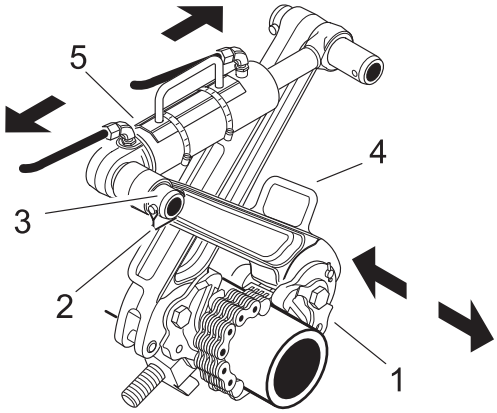
Join



Break

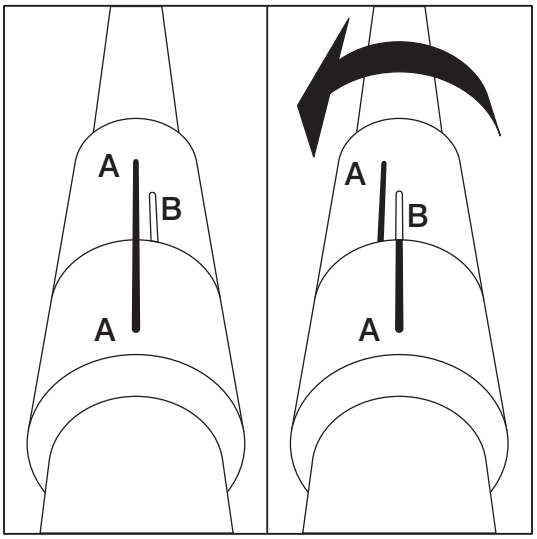
IMPORTANT: Ensure arms are crossed before using wrench.

- Attach chain tongs (1) to both sides of joint. Place tongs as close to joint as possible.
- Remove snapper pins (2) from slide pins (3), and insert slide pins into wrench handles (4).
- Attach each end of hydraulic cylinder (5) to slide pins and insert snapper pins.

3. Remove all slack from wrench and joint.

4. To join, scribe straight line across joint on both sides of separating line (A).
5. To join, scribe second line (B) on moveable side of joint in the opposite direction of tightening action. Refer to table for correct dimension.

Connection	Dimension
transition sub to JT4020 All Terrain pipe	3/8" (9.5 mm)
transition sub to beacon housing	1/2" (13 mm)
transition sub to JT4020 Mach 1 pipe	1/2" (13 mm)



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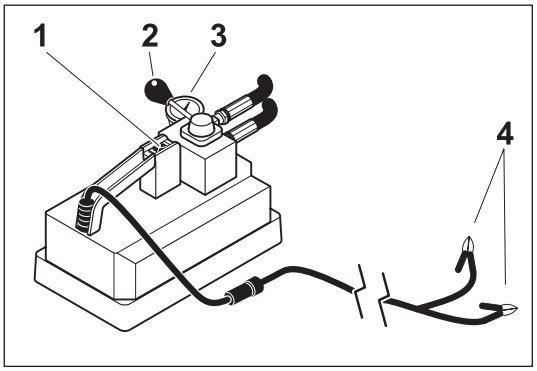
6. Connect Hydratong power pack.
   - Attach hoses from power pack to cylinder.
   - Attach leads (4) to 12V battery.
7. To tighten or loosen joint, move shuttle valve handle (2) toward gauge (3) and press power switch (1).
8. To reposition chain tongs and continue tightening or loosening joint, move handle away from gauge, then back toward gauge, and then press power switch.
9. Monitor gauge and refer to decal to achieve approximately 4000 ft•lb (5420 N•m) of torque. Then tighten joint until second line (B) meets first (A).



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IMPORTANT: Gauge gives an estimate of torque. Use scribe line to get exact torque.

10. Move handle to center (neutral) position to relieve pressure.
11. Disconnect hoses and remove Hydratong components.

Drill Pipe

Perform Regular Drill Pipe Care

Precondition New Pipe

Repeat this procedure **three times** for each piece of pipe before it is used the first time:

1. **Hand-lubricate** entire surface of threads and shoulders of both ends of pipe with copper base tool joint compound. See "Recommended Lubricants/Service Key" on page 178 for correct lubricant.
2. Join pipe and tighten joint.
3. Break joint.
4. Move pipe back to box.

NOTICE: Failure to follow this procedure could result in fused joints. Pipe will be damaged or destroyed.

Lubricate Joints Before Each Use

Lubricate threads and shoulders of male joints with copper base tool joint compound. This prevents rust and reduces wear on shoulders and threads. See "Recommended Lubricants/Service Key" on page 178 for correct lubricant.

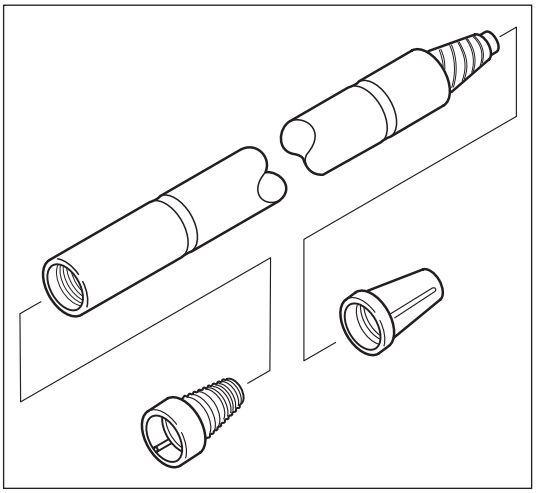
Clean the Threads

Clean the threads as needed with high-pressure water and detergent.

NOTICE: Do not use gasoline or other petroleum-based solvents. This prevents tool joint compound from sticking to the joints and will reduce thread life.

Use Caps and Plugs

Before transporting in dusty conditions or prolonged storage, install caps and plugs to male and female ends of pipe and to saver sub.



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Replace Worn Saver Sub

Because each pipe comes in contact with the saver sub, check saver sub regularly for wear. Replace it when it is worn, or it will damage your drill pipe. See "Lube Saver Sub Wrench Collar and Sliding Output Shaft" on page 196 for replacement procedure.

Precondition a new saver sub the same way you do new pipe. See "Precondition New Pipe" on page 141.

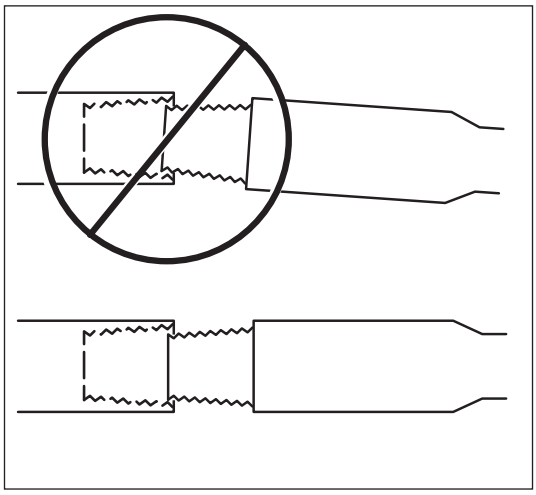
Rotate Pipe Order

Because the lead drill pipe is in the ground longer, it is subjected to higher shock loads and experiences more wear. To help spread this wear evenly over all pipe, move the lead pipe from the previous job to the back of the string, and move every other pipe forward one position.

Use Drill Pipe Correctly

Align the Joints

Always carefully align the male and female ends of pipe before screwing them together. Poor alignment can damage the threads and destroy the usefulness of the joint.



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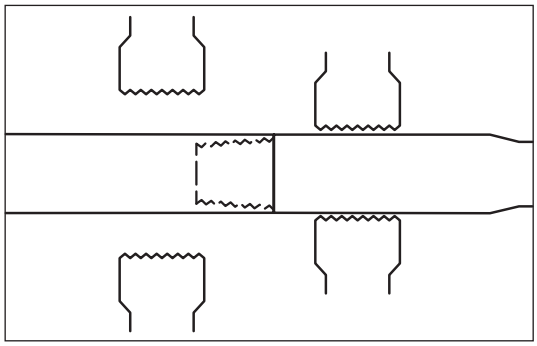
Clamp Pipe Correctly

Clamp on pipe when joint is between wrenches but as near front wrench as possible. Clamp only on the tool joint of the drill pipe as shown. This portion of the drill pipe is designed for clamping and is considerably thicker and stronger than the rest of the pipe.

NOTICE: Clamping anywhere else on the pipe will weaken the pipe. Pipe can later break, even when operating under normal loads.



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See "Clamp Pipe" on page 96 for more information.

Make Up and Break Out Joints Correctly

This consists of two steps:

- **Make up and break out joints slowly.** Do not ram pipes together during makeup or force them apart during breakout. Carefully time rotation with carriage travel speed during makeup, and use floating carriage to lessen stress on threads during breakout. Always connect and disconnect joints slowly and deliberately. This will help prevent thread crossing, galling, and shoulder swelling.
- **Torque joints fully.** Once the joint is connected and the shoulder faces are touching, torque them to full machine torque. Improperly torqued joints will damage the shoulder faces and threads, and will cause joints to leak or break while drilling or backreaming.

Do not Overwork the Pipe

Never exceed the bend radius for your pipe. See "Plan Bore Path" on page 70. Do not oversteer.

NOTICE: Bending pipe more sharply than recommended will damage pipe and cause failure.

Pipe Boxes

Remove/Install Pipe Box

⚠WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

- Lift only one box of pipe at a time.
- Use crane capable of supporting the equipment's size and weight. See page 215 or measure and weigh equipment before lifting.

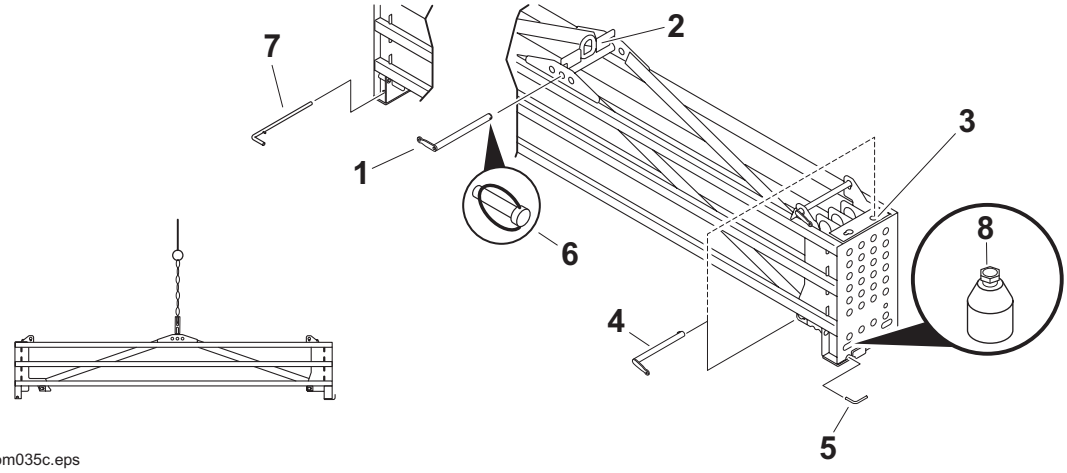
Position Lift Pin Block

The pipe box has 3 lift pin block holes.

- Use center hole to keep pipe box level for transporting pipe boxes and loading onto level drill frame.
- Use side holes to angle box for loading onto angled drill frame.

Remove Pipe Box

1. Insert lift pin block (2) (see page 145) and secure with lift pin (1) and lynch pin (6).
2. Raise pipe with pipe lifter on machine.
3. Move support pins (4) from top of pipe box (3) and insert under both ends of pipe box. Secure with lynch pins.
4. Attach chain to lift pin block.
5. Loosen four pin retainer bolts (8). Two bolts are located on each end of the pipe box.
6. Pull rear pins (5) and front pin (7) and lift box off drill frame. See "Pipe Box" on page 85 for more information.



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Install Pipe Box

IMPORTANT: Reference numbers for this procedure refer to illustration on previous page.

1. Guide pipe box onto centering pin on rear of pipeloader frame. Lower completely onto frame.
2. Insert rear and front pins (5, 7).
3. To bolt pipe box onto drill frame, tighten four retainer bolts (8). Two bolts are located on each end of the pipe box.
4. Raise pipe with pipe lifter on machine.
5. Remove bottom support pins (4) from both ends of pipe box. Store support pins in holes on top of pipe box (3).

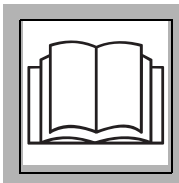
Add/Remove Single Pipe to Pipe Box

Load a single drill pipe or up to a whole row of drill pipe into fourth row of pipe box to finish bore without changing pipe boxes. Pipe can be added as soon as fourth row of pipe has been started and other rows are empty.

⚠ DANGER Electric shock. Contacting electric lines will cause death or serious injury. Know location of lines and stay away.

NOTICE:

- Do not attempt to load and unload pipe while drilling or backreaming. Unprotected worker can be injured by electric strike.
- On electrical jobsite, load and unload pipe only if grid mats are properly set up and connected to drilling unit and loader is wearing electrically insulating boots and gloves.



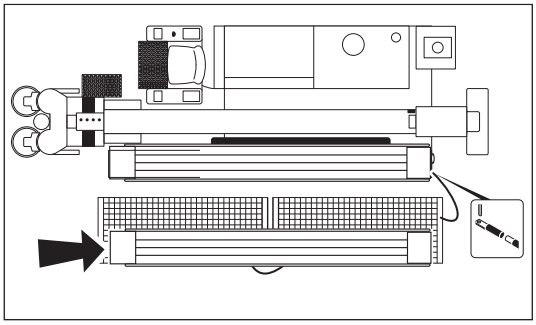
⚠ WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE:

- Open or close **both** auxiliary pipe loaders. Moving shuttles with one auxiliary pipe loader open and one closed will damage equipment and cause possible injury.
- Carriage must be in full back position to load and unload pipe.
- Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.

Add Single Pipe

1. Place grid mats on the ground on pipe box side of drilling unit.
2. Connect mats.
3. Connect bonding cable to drilling unit (shown in inset).
4. Position entire drill pipe box on mat (shown).
5. Ensure shuttle stop is fully lowered.
6. Move shuttles out fully.
7. Pull and hold pins (1) on each shuttle and slide out auxiliary pipe loaders (2).



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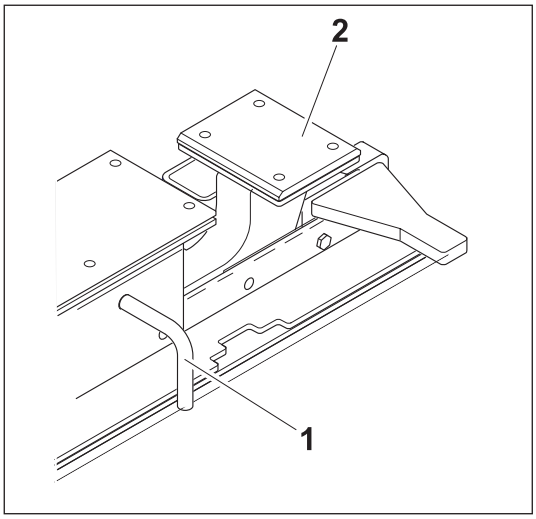

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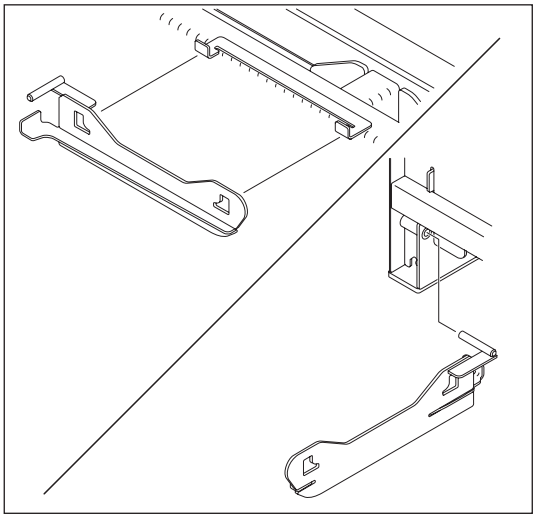
8. Remove pipe stop (stored on outside of drill frame) and attach to front of pipe box.



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WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

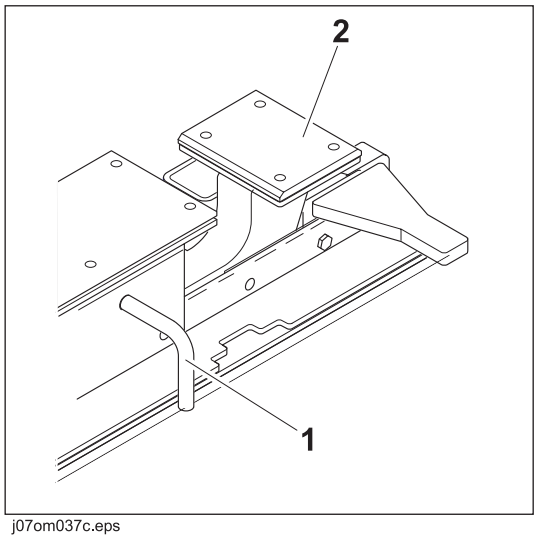
NOTICE: Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.

9. Load a pipe in auxiliary pipe loaders and rest it against pipe stop.
10. Move auxiliary pipe loaders under row 4.
11. Raise pipe into row 4.
12. Move shuttles all the way out.
13. Repeat steps 9-12 to load more pieces of pipe into row 4.
14. Move pipe to pipeloader grippers.
    - Raise last pipe into row 4.
    - Move shuttles out.
    - Lower pipe into front grippers.
15. Before operating pipeloader:
    - Close both auxiliary pipe loaders.
    - Remove pipe stop and store it on drill frame.
    - Step away from drilling unit.

Remove Single Pipe

Unload all drill pipe loaded with auxiliary pipe loaders. Pipe in fourth row of pipe box can be unloaded only when all other rows are empty.

1. Ensure shuttle stop is fully lowered.
2. Move shuttles out fully.
3. Pull and hold pins (1) on each shuttle and slide out auxiliary pipe loaders (2).



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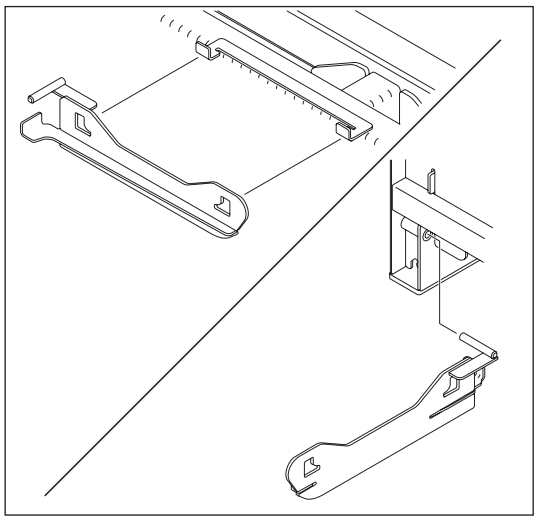
4. Remove pipe stop (stored on outside of drill frame) and attach to front of pipe box.
5. Raise pipe in row 4.
6. Move pipe to auxiliary pipe loaders.
   - Move shuttles in.
   - Lower pipe into auxiliary pipe loaders.
7. Move shuttles out.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WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE: Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.

8. Remove pipe from auxiliary pipe loaders and store properly.
9. Repeat steps 5-8 to unload remaining added drill pipe.
10. After all added drill pipe is unloaded with auxiliary pipe loaders:
    - Close both auxiliary pipe loaders.
    - Remove pipe stop and store it on drill frame.
    - Step away from pipeloader.
    - Finish loading remaining drill pipe into row 4 using standard procedure. See "Remove Pipe" on page 109.

Cruise Control

During the bore, you can set the desired thrust, pullback, and rotation speeds to match ground conditions. Cruise control enables the unit to maintain these settings hands-free. You can engage, disengage, override, and resume these settings at any time.

IMPORTANT: In order for cruise control to function, front wrench must be open and shuttles must be under pipe box.

Engage

Thrust/Pullback and Outer Rotation Control	Thrust/Pullback Control Only
1. Position joystick so that thrust or pullback and outer rotation are at desired speeds. 2. Press SET. Green control cycle light will come on. 3. Release joystick.	1. Position joystick to desired thrust or pullback setting. 2. Press SET. Green control cycle light will come on. 3. Release joystick. 4. Operator controls rotation with joystick.

Adjust Settings

Setting	Instructions
Thrust or Pullback	• To increase thrust or pullback speed while joystick is in neutral position, press RESUME. • To decrease thrust or pullback speed while joystick is in neutral position, press SET.
Outer Rotation	• To increase outer rotation speed, move joystick to left and press RESUME. • To decrease outer rotation speed, move joystick to left and press SET.
Outer Rotation Speed Limit (AT Mode)	**IMPORTANT:** Outer pipe rotation speed is automatically limited when inner rotation is on. • To increase outer rotation speed limit, move joystick to left and press RESUME. • To decrease outer rotation speed limit, move joystick to left and press SET.

Override

- To override settings, move joystick out of neutral and beyond current setting. Unit will increase to new setting.
- To return to previous setting, release joystick.

Disengage

To disengage cruise control, move joystick out of neutral and in opposite direction of carriage travel. Green control cycle light will go off.

Resume

1. Position joystick out of neutral in forward or backward direction.
2. Press RESUME. Green control cycle light will come on.

Machine Diagnostic Codes

Diagnostic Light

Use the red diagnostic light to learn the condition of the diagnostic system. Under normal operating conditions, the diagnostic light will light steadily for two seconds after ignition is turned on to indicate light is working. It will then go out and remain out unless a diagnostic code is recorded.

If diagnostic codes are detected, the diagnostic light will either flash on and off for 10 seconds to indicate a non-essential code or remain on to indicate an essential code.

Code Severity Levels

Diagnostic codes are given one of two levels of severity.

- A **non-essential** code affects non-essential functions of the unit. If the system detects a non-essential problem, a diagnostic code will be recorded and the diagnostic light will flash for 10 seconds and then go out. Each time ignition is turned on, full operation will be available until the diagnostic system detects a problem.
- An **essential** code affects rotation, thrust, drilling fluid, or ground drive. If the system detects an essential problem, a diagnostic code will be recorded and the diagnostic light will cycle on for three seconds and off for 1/2 second. Some machine functions may not work until the problem is corrected. Each time ignition is turned on, full operation will be available until the diagnostic system detects a problem.

Review Modes

IMPORTANT: Do not turn off ignition. Diagnostic codes are cleared each time ignition is turned off.

View All Codes	View Codes Individually
1. Ensure that engine is running and no one is sitting in operator's seat. 2. Press and hold RESUME for two seconds. 3. Diagnostic light will flash code 12 (flash, pause, flash, flash, longer pause) to indicate review mode is operational. 4. After flashing code 12, all diagnostic codes detected since the last time the ignition was turned on are flashed three times each. 5. To save diagnostic codes, continue normal operation. Do not turn ignition off. 6. Once the problem has been corrected, clear all codes by turning ignition off.	1. Ensure that engine is running and no one is sitting in operator's seat. 2. Press and hold SET for two seconds. 3. Diagnostic light will flash code 12 (flash, pause, flash, flash, longer pause) to indicate review mode is operational. 4. After code 12 is flashed, • Press RESUME to see same code again or press SET to see next code. • Continue pressing SET until all diagnostic codes detected since the last time the ignition was turned on are flashed. Cycle is complete when code 12 flashes again. 5. To save diagnostic codes, continue normal operation. Do not turn ignition off. 6. Once the problem has been corrected, clear all codes by turning ignition off.

Diagnostic Code Interpretation

Diagnostic codes are displayed through a series of light flashes and pauses. Count number of flashes and pauses to interpret code.

Example: "Flash, flash, flash, pause, flash, flash, longer pause" represents code 32.

Tips for interpreting codes:

- In View All Codes mode, the green control cycle light will come on the first time the red diagnostic light flashes a code. The green control cycle light will then go off and the red diagnostic light will flash the code two more times.
- Codes are displayed from lower to higher numbers.
- Only numbers 1-5 are used in codes.
- Code 11 is not used.
- Code 12 signals successful entry into and exit from review mode.

Machine Diagnostic Codes

The following table lists the attributes of each diagnostic code. Information presented includes: code number, condition causing code to be sent, result, and level of severity.

Code	Condition	Result	Severity
12	normal review mode entry	code is not stored	n/a
13	no 12V power to controller	drill and drive are blocked	essential
14	no 5V power from controller	drill and drive are blocked	essential
15	unknown output driver continuity problem	code is stored	non-essential
21	no continuity to front wrench clamp solenoid	code is stored	non-essential
23	no continuity to rear wrench clamp solenoid	code is stored	non-essential
25	no continuity to wrench cw rotate solenoid	code is stored	non-essential
31	no continuity to wrench ccw rotate solenoid	code is stored	non-essential
32	no continuity to shuttle extend solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
33	no continuity to shuttle retract solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
34	no continuity to pipe lift solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
35	no continuity to pipe lower solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
41	no continuity to pipe grip solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
42	no continuity to pipe release solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
43	no continuity to lube rear solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
44	no continuity to lube front solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
45	no continuity to carriage two speed solenoid	code is stored	non-essential
51	no continuity to rotation cw solenoid	cruise control is blocked	essential
52	no continuity to rotation ccw solenoid	cruise control is blocked	essential

Code	Condition	Result	Severity
53	no continuity to thrust forward solenoid	cruise control is blocked	essential
54	no continuity to thrust backward solenoid	cruise control is blocked	essential
55	no continuity to left track forward solenoid	drive is blocked	essential
111	no continuity to left track reverse solenoid	drive is blocked	essential
112	no continuity to right track forward solenoid	drive is blocked	essential
113	no continuity to right track reverse solenoid	drive is blocked	essential
114	no continuity to drilling fluid pump solenoid	code is stored	essential
115	no continuity to variable rotation solenoid	code is stored	non-essential
122	no continuity to check valve solenoid	code is stored	non-essential
124	no continuity to inner rotation clockwise solenoid	code is stored	non-essential
125	no continuity to inner rotation counterclockwise solenoid	code is stored	non-essential
131	no continuity to thrust rear home switch	add pipe and remove pipe are blocked	non-essential
132	no continuity to thrust front home switch	add pipe and remove pipe are blocked	non-essential
133	no continuity to shuttle home switch	add pipe and remove pipe are blocked	non-essential
134	no continuity to front wrench switch	add pipe and remove pipe are blocked	non-essential
135	no continuity to hydraulic fan speed sensor	hydraulic fan compensation is blocked	non-essential
144	drive joystick left/right out of range	drive is blocked	essential
145	drive joystick forward/backward out of range	drive is blocked	essential
151	drill joystick left/right out of range	rotation and cruise control are blocked	essential
152	drill joystick forward/backward out of range	thrust and cruise control are blocked	essential

Code	Condition	Result	Severity
154	drilling fluid potentiometer out of range	code is stored	essential
155	rotation potentiometer out of range	code is stored	non-essential
214	no continuity to inner rotation position sensor	dither compensation is blocked	non-essential
221	system voltage is below 12.5V	code is stored	non-essential
222	inner rotation position sensor not changing	dither compensation is blocked	non-essential
223	no continuity to engine fan command signal	hydraulic fan goes to high speed	non-essential
233	drill and drive inputs both on	drill and drive are blocked	essential
234	add pipe and remove pipe inputs both on	add pipe and remove pipe are blocked	non-essential
235	front home and rear home inputs both on	add pipe and remove pipe are blocked	non-essential
241	shuttles not responding correctly	add pipe or remove pipe is aborted and code is stored	non-essential
242	front wrench not responding correctly	add pipe or remove pipe is aborted and code is stored	non-essential
254	error reading setup table information	add pipe and remove pipe are blocked	essential
255	undefinable diagnostic code reported	code is stored	non-essential

Tier 3 Engine

Overview

Tier 3 is a self-diagnostic computer-controlled fuel management system. A variety of sensors send input data to an ECU (Electronic Control Unit) that compares inputs with pre-programed memory and sends output voltage to a variety of actuators to adjust and operate the engine within specified parameters.

Warning indicators on the gauge cluster tell the operator when critical and non-critical faults develop. Non-critical faults occur when engine sensors detect moderate trouble with coolant temperature, oil pressure, charge air temperature, or fuel temperature. Non-critical faults cause the operator alert indicator to light. Critical faults cause the engine shutdown indicator to light. In both cases, a fault code is stored in the ECU. If the fault corrects itself, the engine will gradually return to normal power. The alert indicator will continue to flash until the trouble goes away, but a fault code will remain stored.

Engine shutdown will occur due to critical faults in engine coolant temperature or oil pressure. Before shutdown, the operator alert indicator will light continuously and the engine will begin a rapid power derate. If the fault does not improve in 30 seconds the engine will shut down.

Engine Diagnostic Codes

Problems with the Tier 3 engine usually are indicated by the operator alert indicator on the set-up console and by a diagnostic code displayed on the diagnostic gauge.

IMPORTANT: For more information on the operator alert indicator and how to operate and read the diagnostic gauge, see page 21.

Operator Alert Indicator

When a non-critical engine fault occurs, the operator alert indicator on the gauge cluster will light. A fault code will be stored in the diagnostic gauge.

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Engine Shutdown Indicator

When an critical engine fault occurs, the engine shutdown indicator will light. A fault code will be stored in the diagnostic gauge, and the engine will shut down within 30 seconds.

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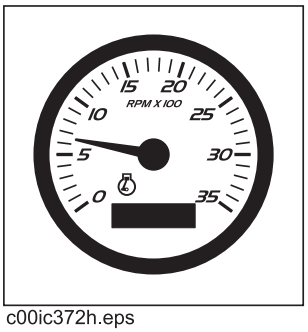
Diagnostic Gauge



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To display codes:

1. Press the selection switch to scroll through the gauge parameters until FMI SPN code is displayed.

   IMPORTANT: For code explanations, see the following page.

2. Press the selection switch to scroll through all codes.

To clear active codes:

1. Turn ignition switch to STOP.
2. Turn ignition switch back to START.

To change display options:

1. Turn the ignition switch to STOP.
2. Press and hold the selection switch.
3. Turn the ignition switch to ON.
4. Press and hold the selection switch to scroll through display options.
5. Release the switch to stop scrolling.
6. To turn options off or on, press the selection switch twice.
7. To save changes, continue scrolling until EXIT CFG is displayed, then press and hold.

Engine Diagnostic Codes

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 629, FMI 12	111	controller # 1	engine control module critical internal failure - bad component
SPN 612, FMI 2	115	system diagnostic code # 2	engine speed/position sensor circuit lost both of two signals from the magnetic pickup sensor - data erratic, intermittent or incorrect.
SPN 122, FMI 3	122	boost pressure	intake manifold pressure sensor circuit - voltage above normal or shorted to high source.
SPN 102, FMI 4	123	boost pressure	intake manifold pressure sensor circuit - voltage below normal or shorted to low source
SPN 100, FMI 3	135	engine oil pressure	oil pressure sensor circuit, voltage above normal or shorted to high source
SPN 100, FMI 4	141	engine oil pressure	oil pressure sensor circuit, voltage below normal or shorted to low source
SPN 100, FMI 18	143	engine oil pressure	oil pressure sensor circuit, voltage below normal operational rage, moderately severe level
SPN 110, FMI 3	144	engine coolant temp	coolant temperature sensor circuit, voltage below normal or shorted to high source
SPN 110, FMI 4	141	engine coolant temp	coolant temperature sensor circuit, voltage below normal or shorted to low source
SPN 110, FMI 16	146	engine coolant temp	coolant temperature high, data valid but above normal operating range, moderately severe level
SPN 110, FMI 0	151	engine coolant temp	coolant temperature low, data valid but below normal operating range, most severe level
SPN 105, FMI 3	153	intake manifold #1 temp	intake manifold air temperature sensor circuit, voltage above normal or shorted to low source
SPN 105-FMI 4	154	intake manifold #1 temp	intake manifold air temperature sensor circuit, voltage above normal or shorted to high source
SPN 105, FMI 0	155	intake manifold #1 temp	intake manifold air temperature sensor circuit, data valid but above normal operational range, most severe level

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 1080, FMI 4	187	5 volts DC supply	sensor supply voltage #2 circuit - voltage below normal, or shorted to low source
SPN 111, FMI 3	195	coolant level	coolant level sensor circuit, voltage above normal or shorted to high source
SPN 111, FMI 4	196	coolant level	coolant level sensor circuit, voltage below normal or shorted to low source
SPN 111, FMI 18	197	coolant level	coolant level, data valid but below normal operational range, moderately severe level
SPN 1484, FMI 31	211	J1939 Error	additional auxiliary diagnostic codes logged, condition exists
SPN 175, FMI 3	212	oil temp	engine oil temp sensor 1 circuit, voltage above normal or shorted to high source
SPN 175, FMI 4	213	oil temp	engine oil temp sensor 1 circuit, voltage below normal or shorted to low source
SPN 175, FMI 0	214	oil temp	engine oil temp, data valid but above normal operational range, most severe level
SPN 108, FMI 3	221	barometric pressure	barometric pressure sensor circuit, voltage above normal or shorted to high source
SPN 108, FMI 4	222	barometric pressure	barometric pressure sensor circuit, voltage below normal or shorted to low source
SPN 1080, FMI 3	227	5 volts DC supply	sensor supply voltage #2 circuit, voltage above normal or shorted to high source
SPN 109, FMI 3	231	coolant pressure	coolant pressure sensor circuit, voltage above normal or shorted to high source
SPN 109, FMI 4	232	coolant pressure	coolant pressure sensor circuit, voltage below normal operation range, moderately severe level
SPN 109, FMI 18	233	coolant pressure	coolant pressure, data valid but below normal operation range, most severe level
SPN 190, FMI 0	234	engine speed	engine speed high, data valid but above normal operational range, most severe level
SPN 111, FMI 1	235	coolant level	coolant level low, data valid but below normal operational range, most severe level

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 644, FMI 2	237	external speed input	external speed input (multiple unit synchronization), data erratic, intermittent or incorrect
SPN 611, FMI 4	238	system diagnostic code # 1	sensor supply voltage #3 circuit, voltage below normal or shorted to low source
SPN 647, FMI 4	245	fan clutch output device driver	fan control circuit, voltage below normal or fan shorted to low source
SPN 171, FMI 3	249	ambient air temp	ambient air temp sensor circuit
SPN 171, FMI 4	256	ambient air temp	ambient air temp sensor circuit, voltage below normal or shorted to low source
SPN 174, FMI 16	261	fuel temp	engine fuel temp, data valid but above normal operational range, moderately severe level
SPN 174, FMI 3	263	fuel temp	engine fuel temp sensor 1 circuit, voltage above normal or shorted to high source
SPN 174, FMI 4	265	fuel temp	engine fuel temp sensor 1 circuit, voltage below normal or shorted to low source
SPN 94, FMI 2	268	fuel delivery pressure	fuel pressure sensor circuit, data erratic, intermittent or incorrect.
SPN 1347, FMI 4	271	fuel pump pressurizing assembly 1	high fuel pressure solenoid valve circuit, voltage below normal or shorted to low source
SPN 1347, FMI 3	272	fuel pump pressurizing assembly 1	high fuel pressure solenoid valve circuit, voltage above normal or shorted to high source
SPN 1347, FMI 7	281	fuel pump pressurizing assembly 1	high fuel pressure solenoid valve 1, mechanical system not responding properly or out of adjustment
SPN 1347, FMI 7	275	fuel pump pressurizing assembly 1	fuel pumping element (front), mechanical system not responding properly or out of adjustment
SPN 1043, FMI 4	284	internal sensor voltage supply	engine speed/position sensor (crankshaft) supply voltage circuit, voltage below normal or shorted to low source
SPN 639, FMI 9	285	SAE J1939 datalink	SAE J1939 multiplexing PGN timeout error, abnormal update rate
SPN 639, FMI 13	286	SAE J1939 datalink	SAE J1939 multiplexing configuration error, out of calibration

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 441, FMI 3	293	OEM temp	auxiliary temp sensor input 1 circuit, voltage above normal or shorted to high source
SPN 441, FMI 4	294	OEM temp	auxiliary temp sensor input 1 circuit, voltage below normal or shorted to low source
SPN 108, FMI 2	295	barometric pressure	barometric pressure sensor circuit, data erratic, intermittent or incorrect
SPN 1388, FMI 14	296	auxiliary pressure	auxiliary pressure sensor input 1, special instructions
SPN 1388, FMI 3	297	auxiliary pressure	auxiliary pressure sensor input 2 circuit, voltage above normal or shorted to high source
SPN 1388, FMI 4	298	auxiliary pressure	auxiliary pressure sensor input 2 circuit, voltage below normal or shorted to low source
SPN 251, FMI 2	319	real time clock power	real time clock power interrupt, data erratic, intermittent or incorrect
SPN 651, FMI 5	322	injector cylinder 01	injector solenoid cylinder 1 circuit, current below normal or open circuit
SPN 655, FMI 5	323	injector cylinder 05	injector solenoid cylinder 5 circuit, current below normal or open circuit
SPN 653, FMI 5	324	injector cylinder 03	injector solenoid cylinder 3 circuit, current below normal or open circuit
SPN 656, FMI 5	325	injector cylinder 06	injector solenoid cylinder 6 circuit, current below normal or open circuit
SPN 652, FMI 5	331	injector cylinder 02	injector solenoid cylinder 2 circuit, current below normal or open circuit
SPN 654, FMI 5	332	injector cylinder 04	injector solenoid cylinder 4 circuit, current below normal or open circuit
SPN 110, FMI 2	334	engine coolant temp	coolant temp sensor circuit, data erratic, intermittent or incorrect
SPN 630, FMI 2	341	calibration memory	engine control module data lost, data erratic, intermittent or incorrect
SPN 630, FMI 13	342	calibration memory	electronic calibration code incompatibility, out of calibration
SPN 629, FMI 12	343	controller 1	engine control module warning internal hardware failure, bad intelligent device or component

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 629, FMI 12	351	controller 1	injector power supply, bad intelligent device or component
SPN 1079, FMI 4	352	5 volts DC supply	sensor supply voltage 1 circuit, voltage below normal or shorted to low source
SPN 1079, FMI 3	386	5 volts DC supply	sensor supply voltage 1 circuit, voltage above normal or shorted to high source
SPN 1043, FMI 3	387	internal sensor voltage supply	accelerator pedal or lever position sensor supply voltage circuit, voltage above normal or shorted to high source
SPN 100, FMI 1	415	engine oil pressure	oil pressure low, data valid but below normal operational range, most severe level
SPN 97, FMI 15	418	water in fuel indicator	water in fuel indicator high, data valid but above normal operational range, least severe level
SPN 111, FMI 2	422	coolant level	coolant level, data erratic, intermittent or incorrect
SPN 175, FMI 2	425	oil temp	engine oil temp, data erratic, intermittent or incorrect
SPN 97, FMI 3	428	water in fuel indicator	water in fuel sensor circuit, voltage above normal or shorted to high source
SPN 97, FMI 4	429	water in fuel indicator	water in fuel sensor circuit, voltage below normal or shorted to low source
SPN 102, FMI 2	433	boost pressure	intake manifold pressure sensor circuit, data erratic, intermittent or incorrect
SPN 627, FMI 2	434	power supply	power lost without ignition off, data erratic, intermittent or incorrect
SPN 100, FMI 2	435	engine oil pressure	oil pressure sensor circuit, data erratic, intermittent or incorrect
SPN 168, FMI 18	441	electrical potential (voltage)	battery 1 voltage low, data valid but below normal operational range, moderately severe level
SPN 168, FMI 16	442	electrical potential (voltage)	battery 1 voltage high, data valid but above normal operational range, moderately severe level
SPN 1043, FMI 4	443	internal sensor voltage supply	accelerator pedal or lever position sensor supply voltage circuit, voltage below normal or shorted to low source

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 157, FMI 0	449	injector metering rail 1 pressure	fuel pressure high, data valid but above normal operational range, moderately severe level
SPN 157, FMI 3	451	injector metering rail 1 pressure	injector metering rail 1 pressure sensor circuit, voltage above normal or shorted to high source
SPN 157, FMI 4	452	injector metering rail 1 pressure	injector metering rail 1 pressure sensor circuit, voltage below normal or shorted to low source
SPN 105, FMI 16	488	intake manifold	intake manifold 1 temp, data valid but above normal operational range, moderately severe level
SPN 1377, FMI 2	497	switch circuit	multiple unit synchronization switch circuit, data erratic, intermittent or incorrect
SPN 611, FMI 2	523	system diagnostic code 1	OEM intermediate (PTO) speed switch validation, data erratic, intermittent or incorrect
SPN 702, FMI 3	527	circuit, voltage	auxiliary input/output 2 circuit, voltage above normal or shorted to high source
SPN 93, FMI 3	528	switch, data	auxiliary alternate torque validation switch, data erratic, intermittent or incorrect
SPN 703, FMI 3	529	circuit, voltage	auxiliary input/output 3 circuit, voltage above normal or shorted to high source
SPN 558, FMI 4	551	accelerator pedal low idle switch	accelerator pedal or lever idle validation circuit, voltage below normal or shorted to low source
SPN 157, FMI 16	553	injector metering rail 1 pressure	fuel pressure sensor error, data erratic, intermittent or incorrect
SPN 157, FMI 18	559	injector metering rail 1 pressure	injector metering rail 1 pressure low, data valid but below normal operational range, moderately severe level
SPN 103, FMI 16	595	turbocharger 1 speed	turbocharger 1 speed high, data valid but above normal operational range, moderately severe level
SPN 167, FMI 16	596	alternate potential (voltage)	electrical charging system voltage high, data valid but above normal operational range, moderately severe level
SPN 167, FMI 18	597	alternate potential (voltage)	electrical charging system voltage low, data valid but below normal operational range, moderately severe level

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 167, FMI 1	598	alternate potential (voltage)	electrical charging system voltage low, data valid but below normal operational range, most severe level
SPN 103, FMI 18	687	turbocharger 1 speed	turbocharger 1 speed low, data valid but below normal operational range, moderately severe level
SPN 190, FMI 2	689	engine speed	primary engine speed sensor error, data erratic, intermittent or incorrect
SPN 1172, FMI 3	691	turbocharger 1 compressor inlet temp	turbocharger 1 compressor inlet temp sensor circuit, voltage above normal or shorted to high source
SPN 1172, FMI 4	692	turbocharger 1 compressor inlet temp	turbocharger 1 compressor inlet temp sensor circuit, voltage below normal or shorted to low source
SPN 1136, FMI 3	697	sensor circuit, voltage	ECM internal temp sensor circuit, voltage above normal or shorted to high source
SPN 1136, FMI 4	698	sensor circuit, voltage	ECM internal temp sensor circuit, voltage below normal or shorted to low source
SPN 22, FMI 3	719	crankcase pressure	extended crankcase blow-by pressure circuit, voltage above normal or shorted to high source
SPN 22, FMI 4	729	crankcase pressure	extended crankcase blow-by pressure circuit, voltage below normal or shorted to low source
SPN 723, FMI 7	731	engine speed sensor 2	engine speed/position 2 mechanical misalignment between camshaft and crankshaft sensors, mechanical system not responding properly or out of adjustment
SPN 723, FMI 2	753	engine speed sensor 2	engine speed/position 2 camshaft sync error, data erratic, intermittent or incorrect
SPN 611, FMI 31	757	electronic control module	electronic control module data lost, condition exists
SPN 723, FMI 2	778	engine speed sensor 2	engine speed sensor (camshaft) error, data erratic, intermittent or incorrect
SPN 166, FMI 2	951	cylinder power	cylinder power imbalance between cylinders, data erratic, intermittent or incorrect
SPN 627, FMI 2	1117	power supply	power lost with ignition on, data erratic, intermittent or incorrect

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 651, FMI 7	1139	injector cylinder 1	Injector cylinder 1, mechanical system not responding properly or out of adjustment
SPN 652, FMI 7	1141	injector cylinder 2	Injector cylinder 2, mechanical system not responding properly or out of adjustment
SPN 653, FMI 7	1142	injector cylinder 3	Injector cylinder 3, mechanical system not responding properly or out of adjustment
SPN 654, FMI 7	1143	injector cylinder 4	Injector cylinder 4, mechanical system not responding properly or out of adjustment
SPN 655, FMI 7	1144	injector cylinder 5	Injector cylinder 5, mechanical system not responding properly or out of adjustment
SPN 656, FMI 7	1145	injector cylinder 6	Injector cylinder 6, mechanical system not responding properly or out of adjustment
SPN 1563, FMI 2	1256	control module identification input state	control module identification input state error, data erratic, intermittent or incorrect
SPN 1563, FMI 2	1257	control module identification input state	control module identification input state error, data erratic, intermittent or incorrect
SPN 157, FMI 0	1911	injector metering rail	injector metering rail 1 pressure, data valid but above normal operational range, most severe level
SPN 32, FMI 3	2111	coolant temp	coolant temp 2 sensor circuit, voltage above normal or shorted to high source
SPN 52, FMI 4	2112	coolant temp	coolant temp 2 sensor circuit, voltage below normal or shorted to low source
SPN 52, FMI 16	2113	coolant temp	coolant temp 2, data valid but above normal operational range, moderately severe level
SPN 52, FMI 0	2114	coolant temp	coolant temp 2, data valid but above normal operational range, most severe level
SPN 2981, FMI 3	2115	coolant pressure	coolant pressure 2 circuit, voltage above normal or shorted to high source
SPN 2981, FMI 4	2116	coolant pressure	coolant pressure 2 circuit, voltage below normal or shorted to low source
SPN 2981, FMI 18	2117	coolant pressure	coolant pressure 2, data valid but below normal operational range, moderately severe level
SPN 611, FMI 3	2185	system diagnostic code 1	sensor supply voltage 4 circuit, voltage above normal or shorted to high source

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 611, FMI 4	2186	system diagnostic code 1	sensor supply voltage 4 circuit, voltage below normal or shorted to low source
SPN 703, FMI 14	2195	auxiliary equipment sensor	auxiliary equipment sensor input 3 engine protection critical, special instructions
SPN 94, FMI 18	2215	fuel delivery pressure	fuel pump delivery pressure, data valid but below normal operational range, moderately severe level
SPN 94, FMI 1	2216	fuel delivery pressure	fuel pump delivery pressure, data valid but above normal operational range, moderately severe level
SPN 630, FMI 31	2217	calibration memory	ECM program memory (RAM) corruption, condition exists
SPN 157, FMI 1	2249	injector metering rail 1 pressure	injector metering rail 1 pressure, data valid but below normal operational range, most severe level
SPN 611, FMI 16	2292	fuel inlet meter device	fuel inlet meter device, data valid but above normal operational range, moderately severe level
SPN 611, FMI 18	2293	fuel inlet meter device	fuel inlet meter device flow demand lower than expected, data valid but below normal operational range, moderately severe level
SPN 633, FMI 31	2311	fuel control valve 1	fueling actuator 1 circuit error, condition exists
SPN 190, FMI 2	2321	engine speed	engine speed/position sensor 1, data erratic, intermittent or incorrect
SPN 723, FMI 2	2322	engine speed sensor 2	engine speed/position sensor 2, data erratic, intermittent or incorrect
SPN 103, FMI 10	2345	turbocharger 1 speed	turbocharger speed invalid rate of change detected, abnormal rate of change
SPN 2789, FMI 15	2346	system diagnostic code 1	turbocharger turbine inlet temp (calculated), data valid but above normal operational range, least severe level
SPN 2629, FMI 15	2347	system diagnostic code 1	turbocharger compressor outlet temp (calculated), data valid but above normal operational range, least severe level
SPN 647, FMI 3	2377	fan clutch output device driver	fan control circuit, voltage above normal or shorted to high source

Two-line diagnostic code	Fault Code	Description	Possible cause
SPN 729, FMI 3	2555	inlet air heater driver 1	intake air heater 1 circuit, voltage above normal or shorted to high source
SPN 729, FMI 4	2556	inlet air heater driver 1	intake air heater 1 circuit, voltage below normal or shorted to low source
SPN 110, FMI 15	2963	engine coolant temp	engine coolant temp high, data valid but above normal operational range, least severe level
SPN 105, FMI 15	2964	intake manifold 1 temp	intake manifold temp high, data valid but above normal operational range, least severe level
SPN 102, FMI 2	2973	boost pressure	intake manifold pressure sensor circuit, data erratic, intermittent or incorrect

Complete the Job

Chapter Contents

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- Add Antifreeze 170
- Reclaim Antifreeze 171

Rinse Equipment 172

Disconnect 173

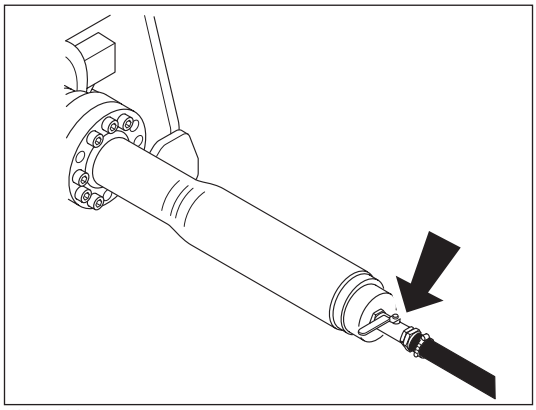
Stow Tools 173

Antifreeze Drilling Unit

Your drilling unit can be left overnight in freezing conditions by circulating a polyproplyene-based antifreeze (p/n 265-644) through unit before shutdown.

Add Antifreeze

1. Fill antifreeze tank with 8 gal (30 L) of approved antifreeze.
2. Install plug on suction side of drilling fluid pump.
3. Open valve below antifreeze tank.
4. Install antifreeze reclaimer adapter in spindle. Ensure valve (shown) is open.
5. Turn drilling fluid potentiometer counterclockwise to zero position.
6. Start unit and set throttle to slow position.
7. Set drilling fluid pump switch to on position.
8. Slowly turn drilling fluid potentiometer clockwise until indicator light comes on.
9. Run drilling fluid pump until antifreeze comes out of spindle.
10. Turn drilling fluid pump switch to off position. Close valve on antifreeze reclaimer adapter.
11. Open valve below right operator's console (shown).
12. Repeat steps 5-8.
13. Close valve below right console when antifreeze runs out of valve below right console.
14. Turn drilling fluid pump switch to off position.



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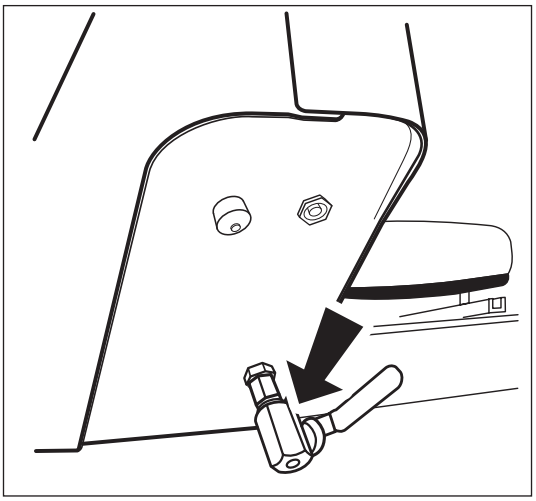

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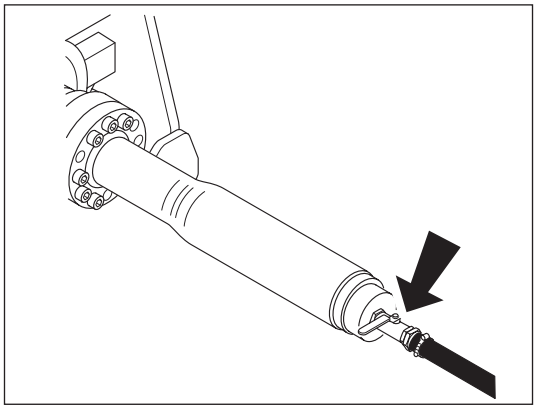
Reclaim Antifreeze

1. Hold hose on antifreeze reclaimer over top of antifreeze tank.
2. Open valve on reclaimer.
3. Connect drilling fluid transfer hose from tanks to drilling fluid pump inlet.
4. Close valve below antifreeze tank.
5. Start unit and run at low throttle.
6. Turn drilling fluid pump on low speed.
7. Turn drilling fluid pump off when drilling fluid comes out of reclaimer hose.
8. Remove antifreeze reclaimer.



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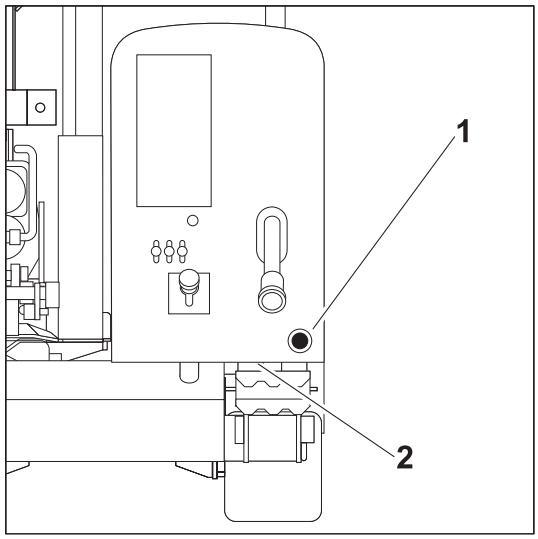
IMPORTANT: Antifreeze can be removed from antifreeze tank and disposed of properly or it can be reused until it is too diluted with drilling fluid to protect against freezing.

Rinse Equipment

Using Washwand

Connect the washwand at quick connect (1) at rear of unit. Open valve (2) to start water flow. Close valve to stop water flow.



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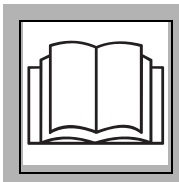
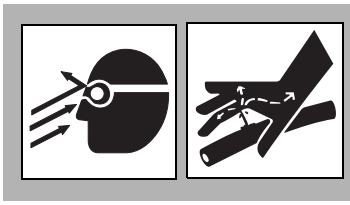


WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE: Failure to prime the drilling fluid pump will cause flow fluctuations, which will make it difficult to control the washwand. For instructions, see "Prime Drilling Fluid Pump" on page 94.



WARNING Pressurized fluid or air could pierce skin and cause injury or death. Stay away.

Spray water onto equipment to remove dirt and mud. Some pressure might be needed to remove dried mud from wrench area.

NOTICE: Do not spray water onto operator's console. Electrical components could be damaged. Wipe down instead.

Disconnect

Disconnect and store the following hoses and cables (if used):

- electric cable
- electric strike system voltage stake
- fluid hose

Stow Tools

Make sure all Hydratong wrenches, bits, pullback devices, and other tools are loaded on trailer.

Service

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- Welding Precaution 176
- Washing Precaution 176
- Working Under Drilling Unit 177

Recommended Lubricants/Service Key 178

- Engine Oil Temperature Chart 179
- Approved Coolant 179

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25 Hour 188

50 Hour 189

250 Hour 195

500 Hour 196

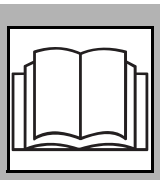
1000 Hour 199

2000 Hour 203

5000 Hour 204

As Needed 205

Service Precautions



WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICES:

- Unless otherwise instructed, all service should be performed with engine off.
- Refer to engine manufacturer's manual for engine maintenance instructions.

Welding Precaution

NOTICE: Welding can damage electronics.

- Welding currents can damage electronic components. Always disconnect the ECU ground connection from the frame, harness connections to the ECU, and other electronic components prior to welding on machine or attachments. Connect welder ground close to welding point and make sure no electronic components are in the ground path. We recommend that NO WELDING signs be prominently displayed on machine.
- Disconnect battery at battery disconnect switch before welding to prevent damage to battery.
- Do not turn off battery disconnect switch with engine running, or alternator and other electronic devices may be damaged.

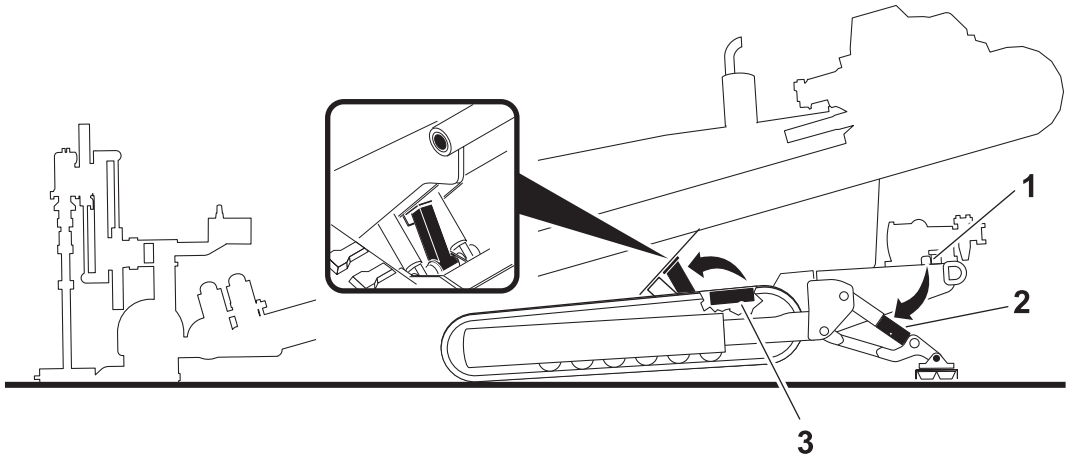
Washing Precaution

NOTICE: Water can damage electronics. When cleaning equipment, do not spray electrical components with water.

Working Under Drilling Unit

WARNING Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away.

Use safety supports as indicated when working under drilling unit.



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Before working under **front end of drill frame**, install jackstands under frame.

Before working under area of drilling unit **supported by a stabilizer**, make sure drilling unit is parked on hard surface.

1. Remove cylinder lock pinned to frame (1) and place over extended cylinder rod (2).
2. Reinstall pins to secure cylinder lock to rod.
3. Raise stabilizer until load is supported by cylinder lock.

Before working under area of drilling unit **supported by frame tilt cylinder**, make sure drilling unit is parked on hard surface.

1. Remove drill frame support tube stored under frame (3) and place under drill frame (shown in inset).
2. Lower drill frame until load is supported by drill frame support tube.

Recommended Lubricants/Service Key

Item	Description
DEO	SAE 15W40 multi-viscosity diesel engine oil meeting or exceeding API service classification CH-4 or ACEA specification E3
NDO	SAE 30 non-detergent engine oil
MPG	Multipurpose grease meeting ASTM D217 and NLGI 5
MPG	Pump seal grease, similar to 94050 Philube blue multipurpose
MPL	Multipurpose gear oil meeting API service classification GL-5 (SAE 80W90)
THF	Tractor hydraulic fluid, similar to Phillips 66 HG, Mobilfluid 423, Chevron Tractor Hydraulic Fluid, Texaco TDH Oil, or equivalent
TJC	Tool joint compound: Ditch Witch standard (p/n 259-858) or summer grade (p/n 256-031)
DEAC	Diesel engine antifreeze/coolant meeting ASTM D5345 (prediluted) or D4985 (concentrate)
	Check level of fluid or lubricant
	Check condition
	Filter
	Change, replace, adjust, service or test

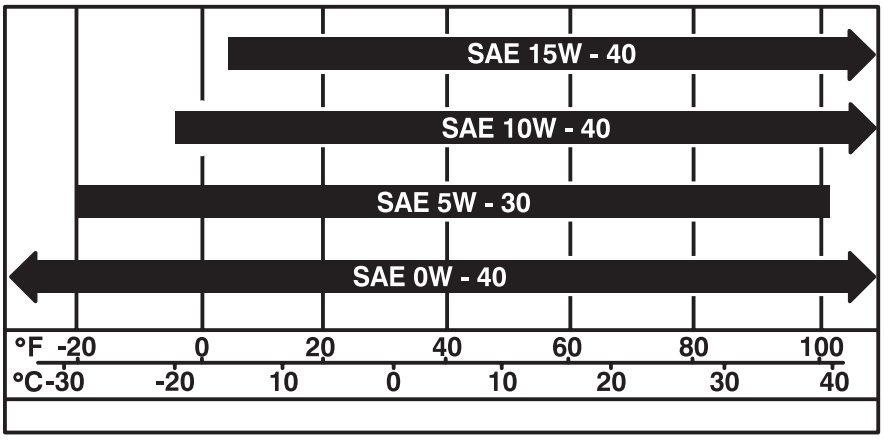
Proper lubrication and maintenance protects Ditch Witch equipment from damage and failure. Service intervals listed are for minimum requirements. In extreme conditions, service machine more frequently. Use only recommended lubricants. Fill to capacities listed in "Fluid Capacities" on page 217.

For more information on engine lubrication and maintenance, see your engine manual.

NOTICE:

- Use only genuine Ditch Witch parts, filters, approved lubricants, TJC, and approved coolants to maintain warranty.
- Use the "Service Record" on page 223 to record all required service to your machine.

Engine Oil Temperature Chart



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Temperature range anticipated before next oil change

Approved Coolant

This unit was filled with coolant before shipment from factory. Add only fully-formulated, ethylene glycol based, low-silicate, heavy-duty diesel engine coolant meeting ASTM specification D5345 (prediluted) or D4985 (concentrate).

NOTICE:

- Do not use water or high-silicate automotive-type coolant. This will lead to engine damage or premature engine failure.
- Do not mix heavy-duty diesel engine coolant and automotive-type coolant. This will lead to coolant breakdown and engine damage.
- Use only distilled water for mixing coolants. Do not use tap water.

Each Use

Location	Task	Notes
DOWNHOLE TOOLS	Lube drill head	pump seal grease (p/n 256-036)

NOTICE: See "Drill Pipe" on page 141 for information and precautions regarding drill pipe.

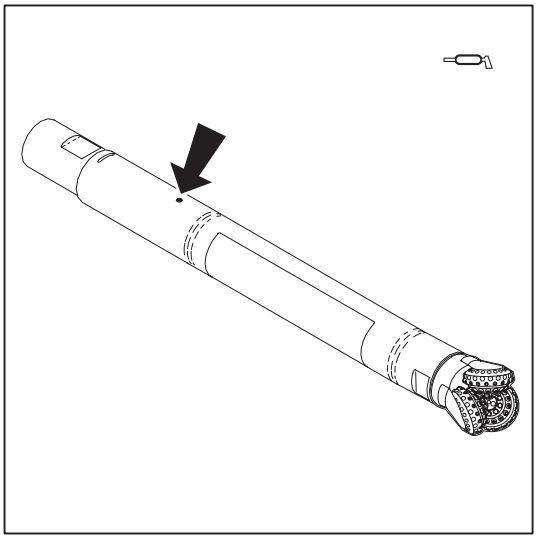
Downhole Tools

Lube Drill Head

Lube drill head with pump seal grease (p/n 256-036) every 8 hours and after every bore.

To lube:

1. Remove hex plug.
2. Install zerk.
3. Rotate drill head by hand and fill with pump seal grease until it comes out at front seal.
4. Remove zerk.
5. Replace hex plug.



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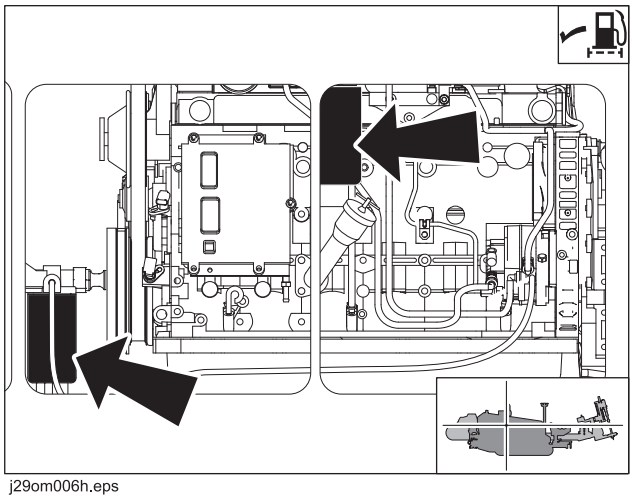
10 Hour

Location	Task	Notes
DRILLING UNIT	Check fuel filter water separators	
	Check engine oil level	DEO
	Check engine coolant level	DEAC
	Check air filter indicator and clean dust trap	
	Check hydraulic hoses	
	Check hydraulic fluid level	THF
	Check fluid pump oil level	SAE 30 NDO
	Test control switches	
	Check pipe lube applicator	
	Check pipe auto lubricator spray nozzle	
	Check pipe auto lubricator TJC level	TJC
	Check drilling fluid y-strainer	

Drilling Unit

Check Fuel Filter Water Separators

Check fuel filter water separators every 10 hours. Drain water at plug as needed.



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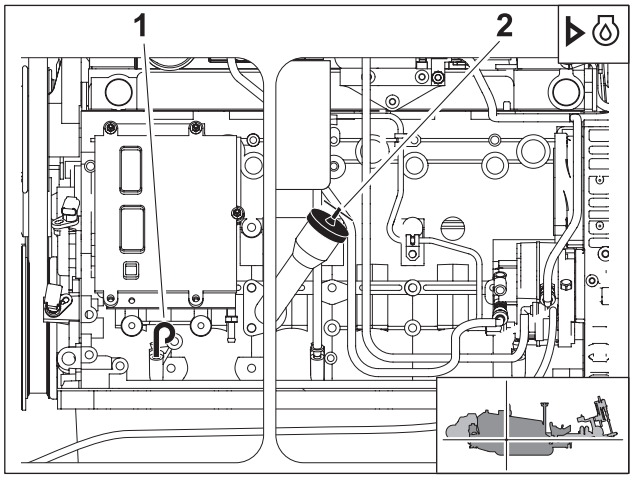
Check Engine Oil Level

Check engine oil at dipstick (1) every 10 hours. If low, fill with DEO at oil fill (2)

IMPORTANT: See "Recommended Lubricants/ Service Key" on page 178 for more information on engine oil.



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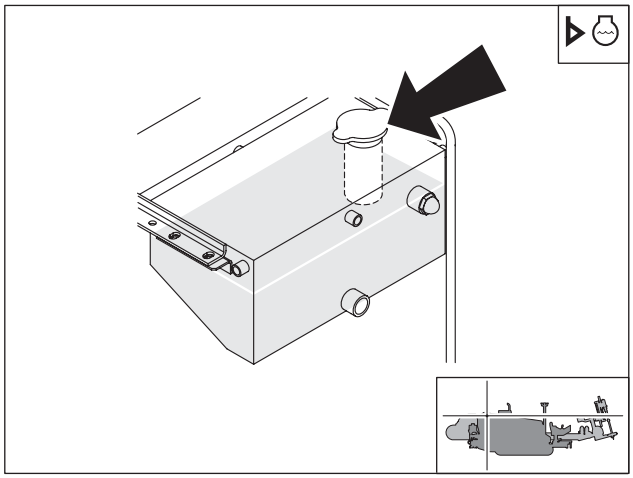
Check Engine Coolant Level

With engine cool, check coolant level at fill neck in expansion tank every 10 hours. Maintain coolant level at bottom of fill neck. If low, fill with approved coolant.

IMPORTANT: See "Approved Coolant" on page 179 for information on approved coolant.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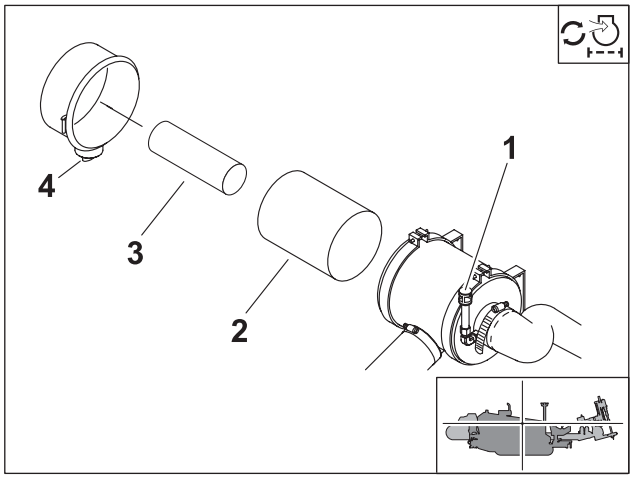
Check Air Filter Indicator and Clean Dust Trap

Check air filter indicator (1) and clean dust trap (4) every 10 hours. Change filter elements (2, 3) when red flag pops up. Reset air filter service indicator after changing filter.



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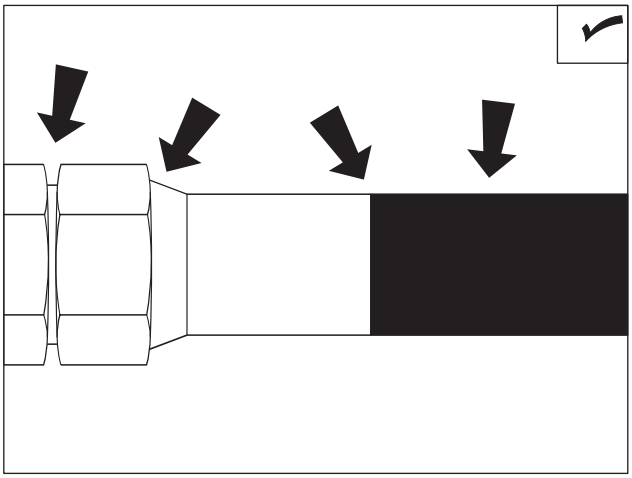
Check Hydraulic Hoses

Check hydraulic hoses for leaks every 10 hours.



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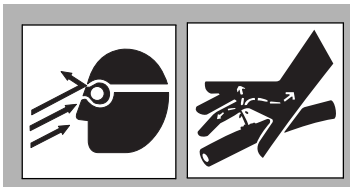


WARNING Pressurized fluid or air could pierce skin and cause injury or death. Stay away.

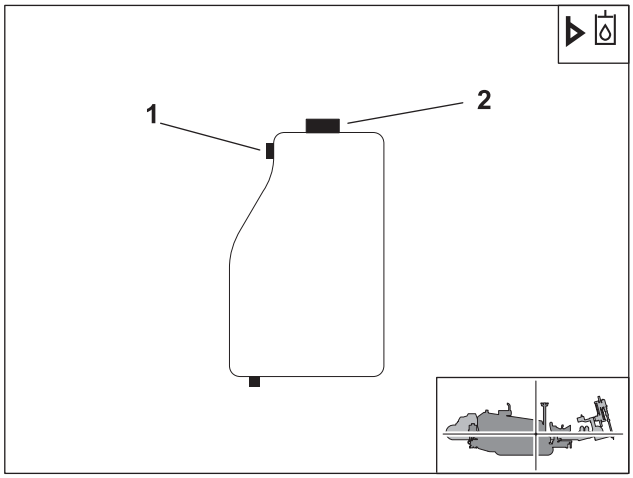
NOTICE: Escaping pressurized fluid can cause injury or pierce skin and poison.

- Before disconnecting a hydraulic line, turn engine off and operate all controls to relieve pressure. Lower, block, or support any raised component with a hoist. Cover connection with heavy cloth and loosen connector nut slightly to relieve residual pressure. Catch all fluid in a container.
- Before using system, check that all connections are tight and all lines are undamaged.
- Fluid leaks can be hard to detect. Use a piece of cardboard or wood, rather than hands, to search for leaks.
- Wear protective clothing, including gloves and eye protection.
- If you are injured, seek immediate medical attention from a doctor familiar with this type of injury.

Check Hydraulic Fluid Level

Check hydraulic fluid level every 10 hours. Maintain fluid level at halfway point on sight glass (1), when engine is off and fluid is cool. Refill with THF at hydraulic fluid fill (2).

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.



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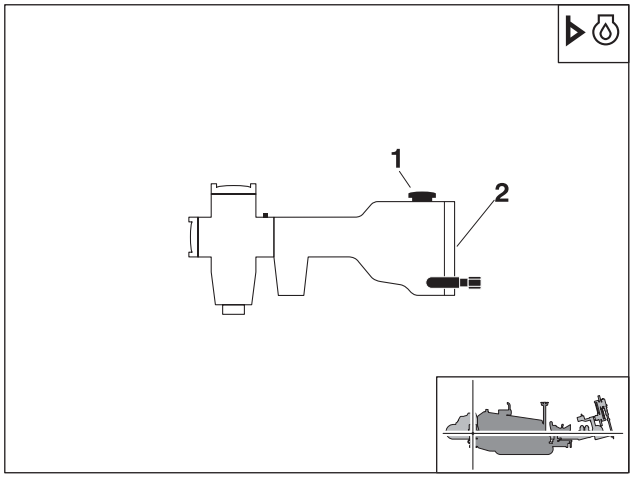
Check Fluid Pump Oil Level

Check fluid pump oil level at sight glass or petcock (2) every 10 hours. Maintain fluid level at halfway point on sight glass or at petcock level. Fill at cap (1) with SAE 30 non-detergent engine oil.



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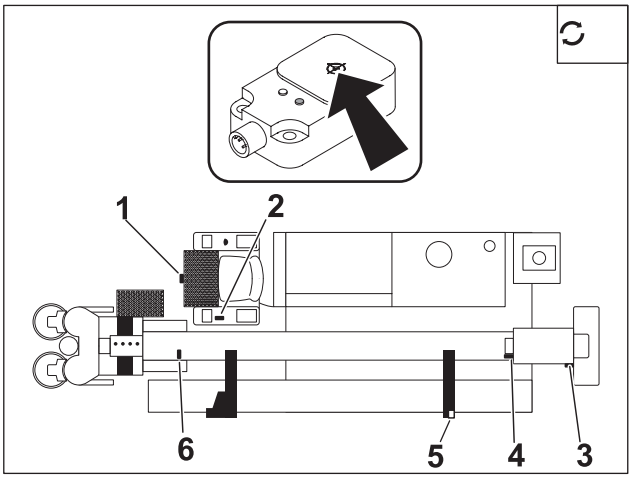
Test Control Switches

Test control proximity switches every 10 hours.

1. Drive position switch
2. Drill position switch
3. Rear stop switch
4. Rear home switch
5. Shuttle home switch
6. Front home switch



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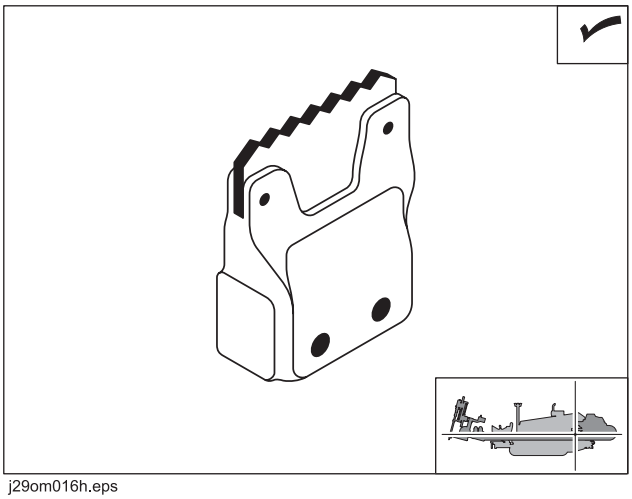
To test:

1. Turn ignition switch to the on position. Do not start engine.
2. Place metal object above target on each switch.
3. If yellow LED on switch lights, switch sensor is working.

Check Pipe Lube Applicator

Check pipe lube applicator every 10 hours. Replace if damaged or badly worn.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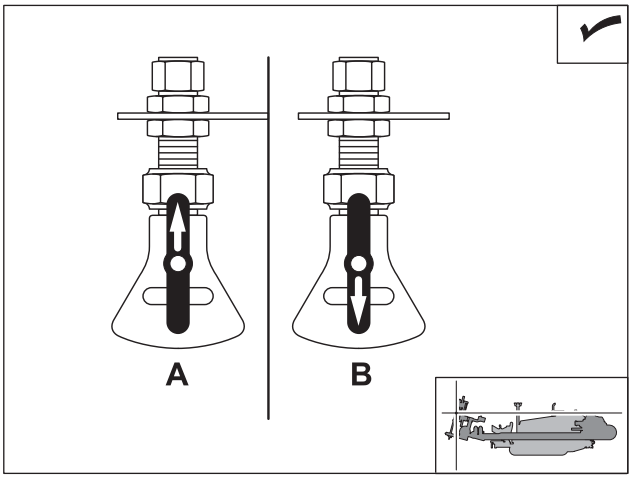
Check Pipe Auto Lubricator Spray Nozzle



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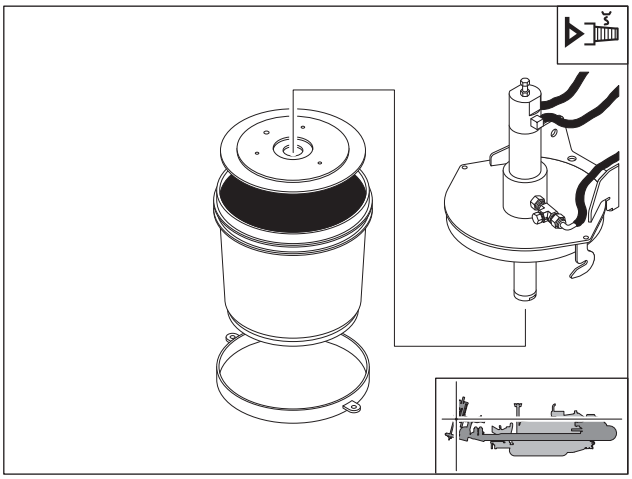
Check pipe auto lubricator spray nozzle every 10 hours. Ensure that nozzle is free of obstructions and operates properly. Clean as needed.

NOTICE: Ditch Witch tool joint compound is specially formulated to work with Ditch Witch pipe lubrication system. Use of other tool joint compounds will clog system. See "Recommended Lubricants/Service Key" on page 178 for more information.

To clean:

1. Rotate handle to the upward, or cleanout, position (A).
2. Operate pump until obstruction is flushed.
3. Rotate handle to the downward, or spray, position (B).
4. Clean nozzle guard. If necessary, pull handle/nozzle insert out of housing to clean with fine wire or solvent.

Check Pipe Auto Lubricator TJC Level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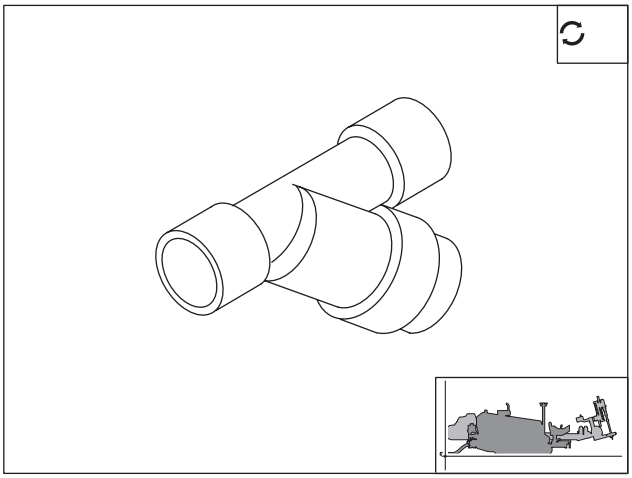
Check pipe auto lubricator TJC level every 10 hours. Change pail as needed. See "Change Auto Lubricator TJC Pail" on page 206 for procedure

NOTICE: Ditch Witch tool joint compound is specially formulated to work with Ditch Witch pipe lubrication system. Use of other tool joint compounds will clog system. See "Recommended Lubricants/Service Key" on page 178 for more information.

Clean Drilling Fluid Y-Strainer

Clean drilling fluid y-strainer every 10 hours. Ensure that strainer is free of debris.



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25 Hour

Location	Task	Notes
DOWNHOLE TOOLS	Rebuild 2° tool	2500' (760 m)

Downhole Tools

Rebuild 2° Tool

Rebuild downhole tool every 25 hours or 2500' (760 m) as measured by inner rotation hourmeter. Use rebuild kit (p/n 191-120) or seal kit (p/n 191-239) available at your Ditch Witch dealer.

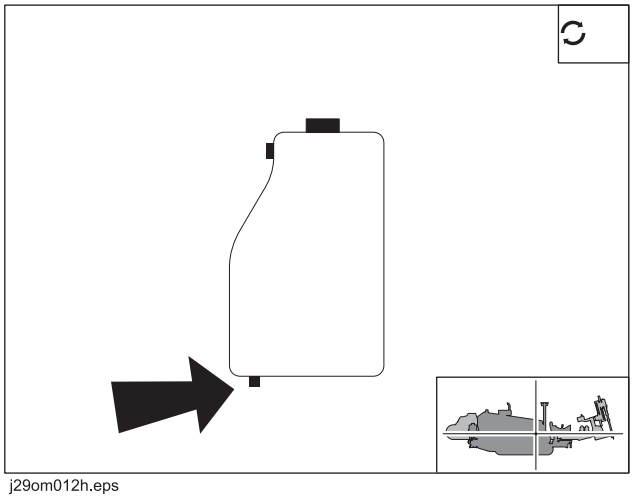
50 Hour

Location	Task	Notes
DRILLING UNIT	Drain water from hydraulic tank	
	Change fluid pump oil	initial service, SAE 30 NDO
	Change hydraulic filters	initial service
	Check ground drive gearbox oil level	2 gearboxes, MPL
	Check rotation gearbox oil level	MPL
	Check thrust drive gearbox oil level	4 gearboxes, MPL
	Check radiator for debris	
	Lube vise wrenches	MPG
	Lube saver sub wrench collar and sliding output shaft	EPL (spray)
	Check hex	
DOWNHOLE TOOLS	Rebuild 1.5° and grade tools	5,000' (1524 m)

Drilling Unit

Drain Water from Hydraulic Tank

Drain water out of tank every 50 hours. To drain, turn plug slightly until water comes out. After all water has drained, tighten plug.



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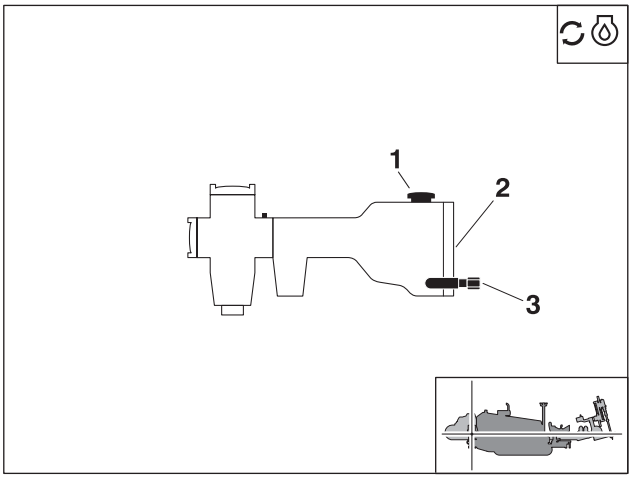
Change Fluid Pump Oil (Initial Service)

Change fluid pump oil after first 50 hours and every 1000 hours thereafter. Maintain fluid level at halfway point on sight glass or at petcock level (2). Drain at plug (3). Fill at cap (1) with SAE 30 non-detergent engine oil. Capacity for 70 gpm pump is 4 qt (3.8 L). Capacity for 120 gpm pump is 10 qt (9.4 L).



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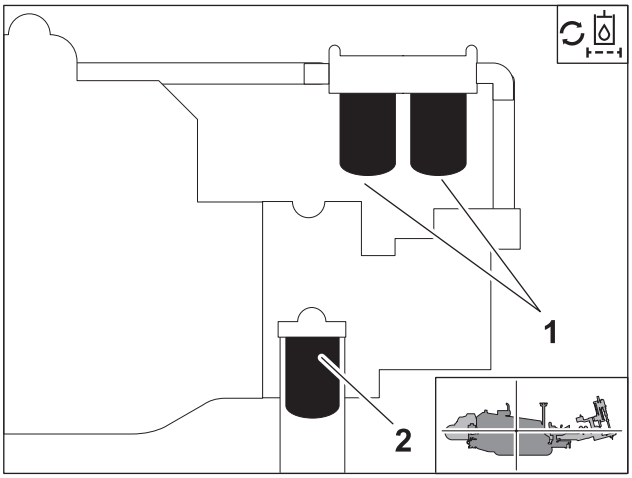
Change Hydraulic Filters (Initial Service)

Change three hydraulic filters after first 50 hours. Replace filters every 250 hours thereafter. Change filters more often if indicated by filter indicator.

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.



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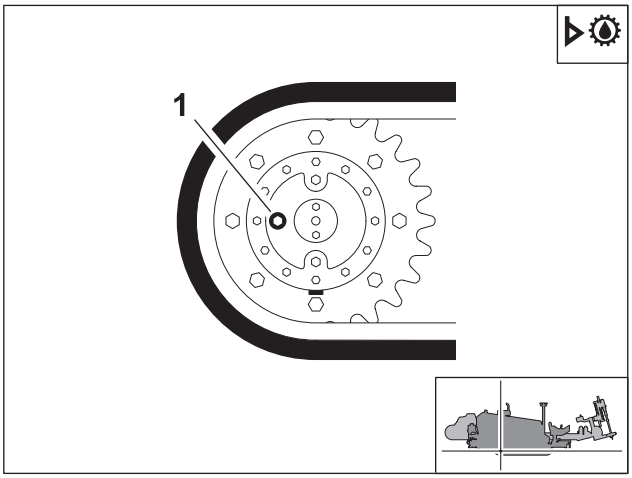
Check Ground Drive Gearbox Oil Level



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Check oil level in both ground drive gearboxes every 50 hours.

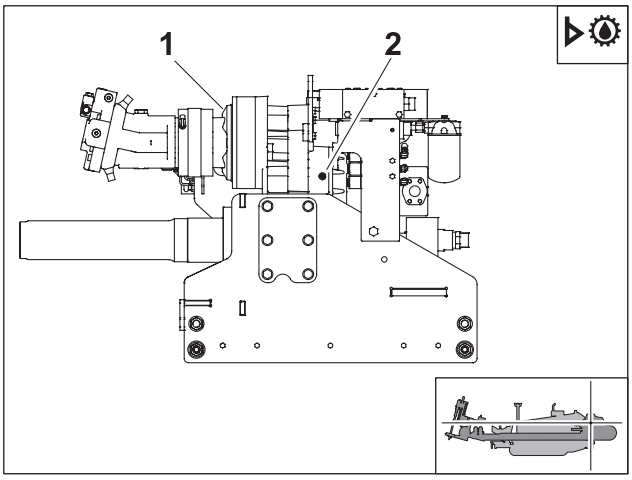
To check:

1. Drive unit to rotate plug (1) until level with center of gearbox.
2. Open plug and fill with MPL until level with plug opening.
3. Replace plug.

IMPORTANT:

- Drilling unit must be on level ground for accurate reading.
- Use helper to assist in positioning gearbox plugs for checking and adding oil.
- Do not overfill.

Check Rotation Gearbox Oil Level



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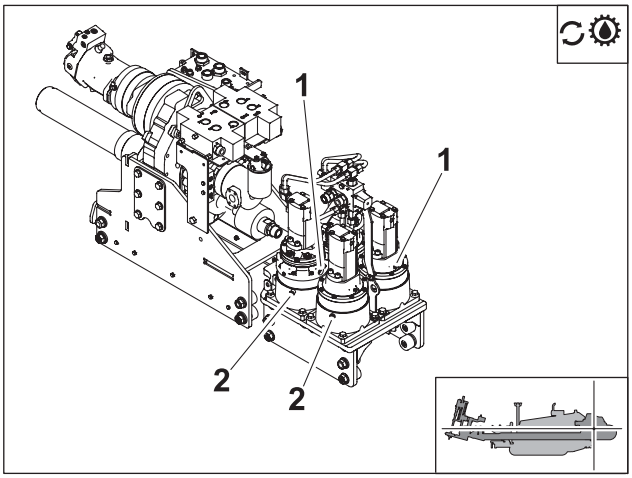
Check rotation gearbox oil level every 50 hours. Fill through plug (1) to level of sight plug (2) with MPL as needed.

IMPORTANT: Drill frame must be level for accurate reading.

Check Thrust Drive Gearbox Oil Level

Check oil level in four thrust drive gearboxes every 50 hours. Fill to level of fill plug (1) with MPL as needed.

IMPORTANT: Drill frame must be level for accurate reading.



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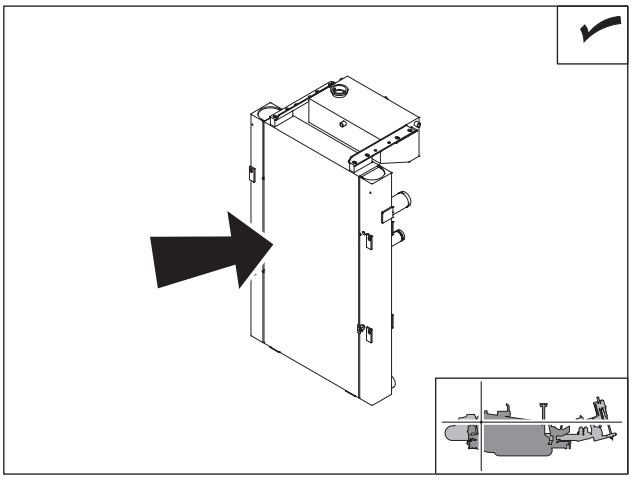
Check Radiator For Debris

Check radiator for dirt, grass, and other foreign matter every 50 hours. Clean out with compressed air or spray wash if required. Be careful not to damage fins with high-pressure air or water. Check more often if operating in dusty or grassy conditions.

NOTICE: Be careful not to damage fins with high pressure air or water.



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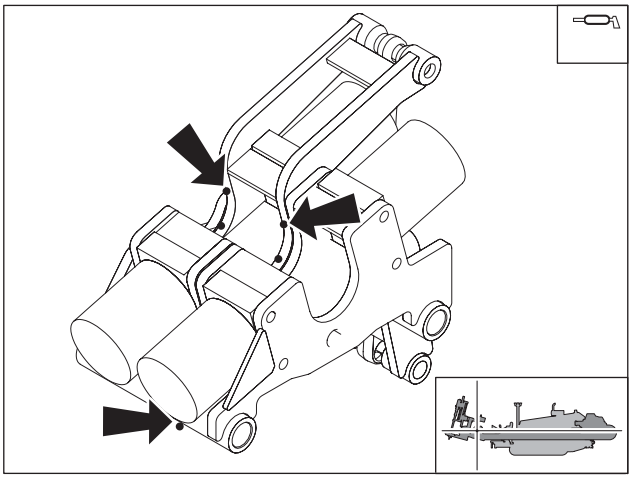
Lube Vise Wrenches

Lube ten zerks with MPG every 50 hours.



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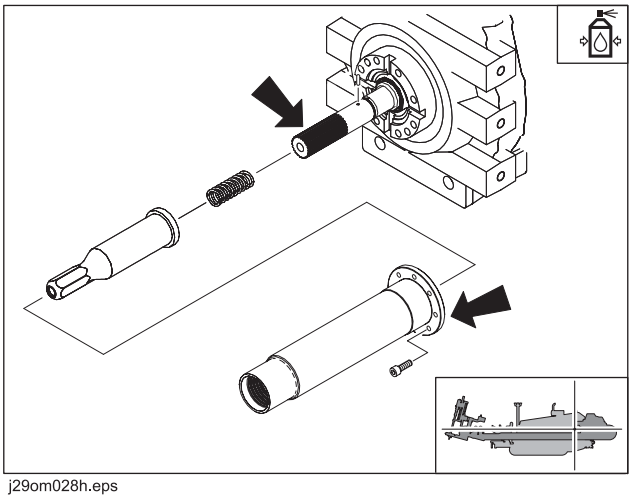
Lube Saver Sub Wrench Collar and Sliding Output Shaft

Lube with EPL spray every 50 hours.



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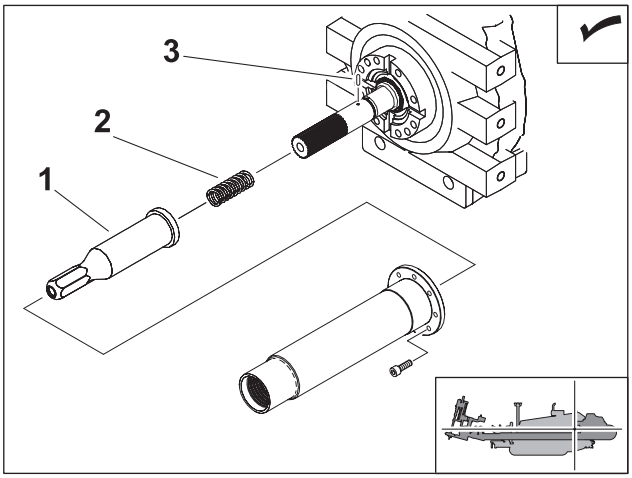
Check Hex



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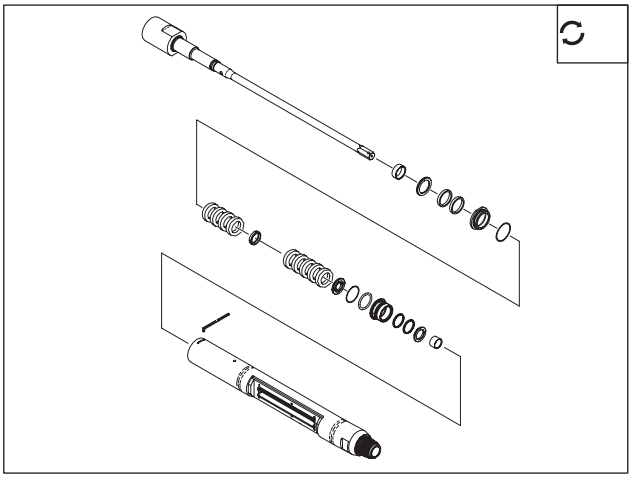
Shine flashlight into spindle and check condition of hex (1) every 50 hours. Replace if rounded.

To replace:

1. Remove saver sub. Do not remove indexing dowels from spindle.
2. Slide hex (1) and spring (2) off of drive shaft.
3. Check condition of drive pin (3) and replace if needed.
4. Check o-ring on inner water swivel (seal kit) and replace if needed.
5. Install new spring and hex.
6. Install saver sub. See page 211.

Downhole Tools

Rebuild 1.5° and Grade Tools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Rebuild downhole tool every 50 hours or 5,000' (1524 m) as measured by inner rotation hourmeter. Use rebuild kit (p/n 191-120) or seal kit (p/n 191-239) available at your Ditch Witch dealer.

250 Hour

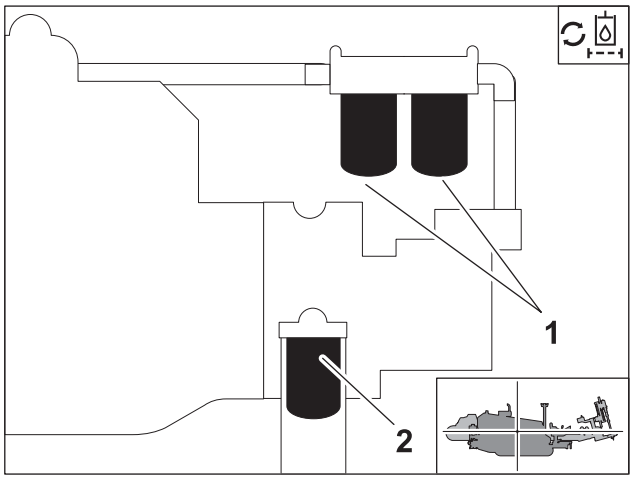
Location	Task	Notes
DRILLING UNIT	Change hydraulic filters	

Drilling Unit

Change Hydraulic Filters

Change three hydraulic filters (1, 2) every 250 hours. Change filters more often if indicated by filter indicator.

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.



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500 Hour

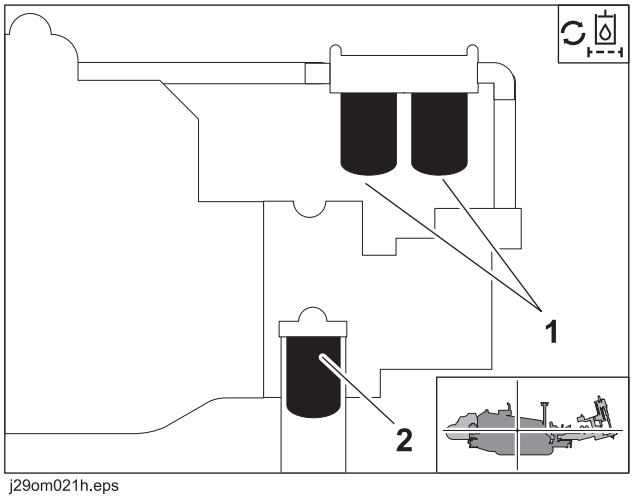
Location	Task	Notes
DRILLING UNIT	Change hydraulic fluid and filters	extreme temperatures
	Change engine oil and filter	DEO
	Change fuel filters	
	Check batteries	

Drilling Unit

Change Hydraulic Fluid and Filters (Extreme Temperatures)

Change hydraulic fluid and three filters every 500 hours if jobsite temperature exceeds 100° F (38° C) more than 50% of the time. Drain hydraulic fluid, change filters (1, 2), and refill with THF at hydraulic fluid fill. Tank capacity is 36 gal (136 L).

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.



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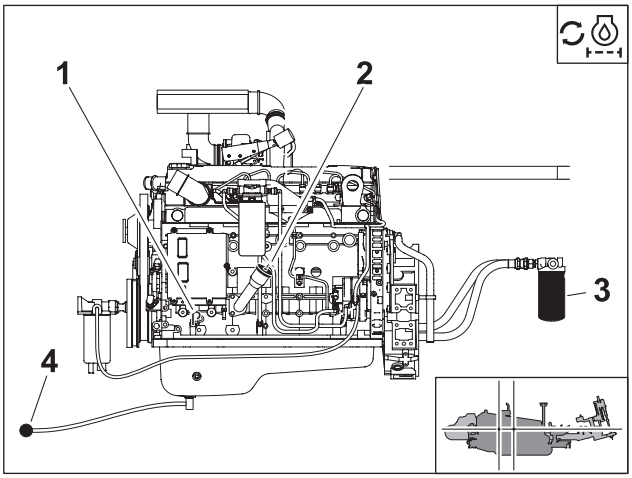
Change Engine Oil and Filter

Change engine oil and filter (3) every 500 hours. Drain oil (4), change filter (3), and refill with 24 qt (21 L) of DEO at fill (2). Capacity is 20.1 qt (19 L). Check oil at dipstick (1).

IMPORTANT: Except as noted above, use oil specified in temperature chart found in "Recommended Lubricants/Service Key" on page 178.



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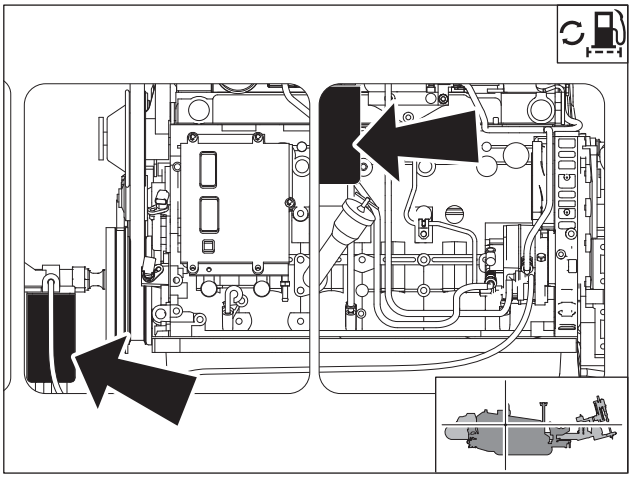
Change Fuel Filters

Replace fuel filters every 500 hours. See parts manual or contact your Ditch Witch dealer for correct replacement filters.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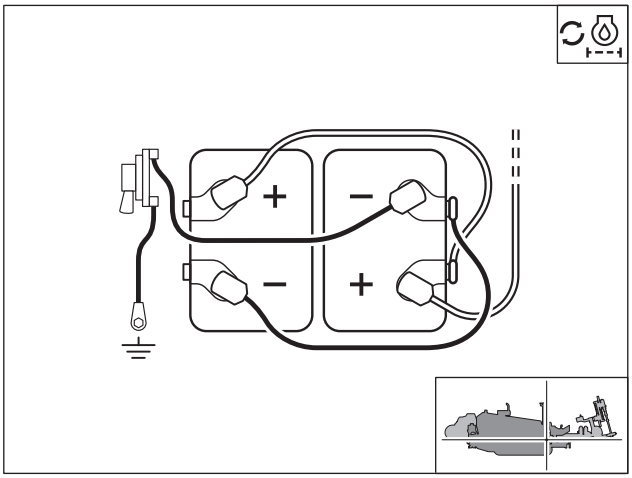
Check Batteries



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Check batteries every 500 hours. Keep batteries clean and terminals free of corrosion.

To clean:

1. Turn battery disconnect switch to off position.
2. Ensure that no ignition sources are near batteries.
3. Loosen and remove battery cable clamps carefully, **negative (-)** cable first.
4. Clean cable clamps and terminals with wire brush or battery cleaning tool to remove dull glaze.
5. Check for signs of internal corrosion in cables.
6. Apply MPG to terminals after cleaning to reduce corrosion.
7. Connect battery cable clamps, **positive (+)** cable first.
8. Tighten any loose connections.
9. Ensure that battery tiedowns are secure.
10. Turn battery disconnect switch to on position.

WARNING Explosion possible. Serious injury or equipment damage could occur. Follow directions carefully.

NOTICE: To avoid explosion, do not create sparks and do not short across battery terminals for any reason.

1000 Hour

Location	Task	Notes
DRILLING UNIT	Change hydraulic fluid and filters	normal conditions
	Change ground drive gearbox oil	2 gearboxes, MPL
	Change rotation gearbox oil	MPL
	Change spindle brake oil	THF
	Change fluid pump oil	SAE 30 non-detergent
	Lube saver sub wrench collar and sliding output shaft	EPL (gel)
	Check engine drive belt	

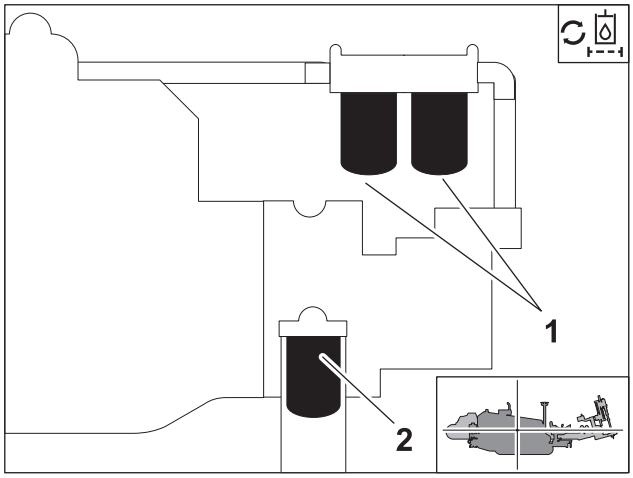
Drilling Unit

Change Hydraulic Fluid and Filters (Normal Conditions)

Change hydraulic fluid and three filters every 1000 hours for normal service. Drain hydraulic fluid, change filters (1, 2), and refill with THF at hydraulic fluid fill. Tank capacity is 36 gal (136 L).

IMPORTANT:

- If ambient temperature exceeds 100°F (37°C) for 50% of time, change oil and filter every 500 hours.
- If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.



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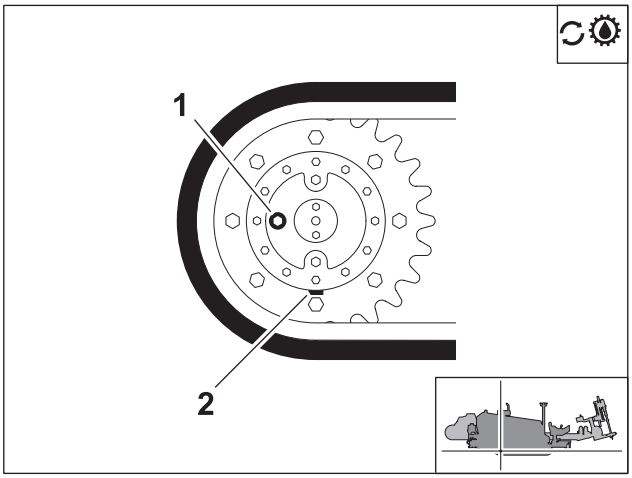
Change Ground Drive Gearbox Oil

Change oil in both ground drive gearboxes every 1000 hours. Capacity is 1.6 qt (1.5 L).

To change:

1. Remove drain plug (2) and drain oil.
2. Replace drain plug.
3. Drive unit to rotate fill plug (1) until level with center of gearbox.
4. Open fill plug and fill with MPL until level with plug opening.
5. Replace fill plug.



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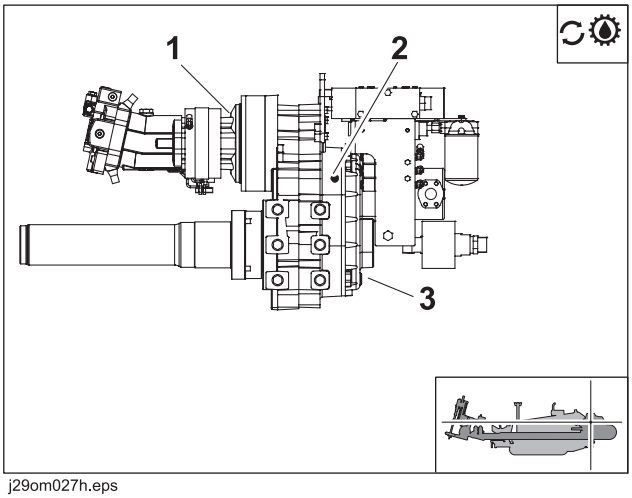
IMPORTANT:

- Drill frame must be level for accurate reading.
- Use helper to assist in positioning gearbox plugs for checking and adding oil.
- Do not overfill.

Change Rotation Gearbox Oil

Drain oil at gearbox oil drain (3) every 1000 hours. Fill with MPL at fill plug (1) until oil is level with sight plug opening (2). Replace plugs. Capacity is 9 qt (8.5 L).

IMPORTANT: Drill frame must be level for accurate reading.



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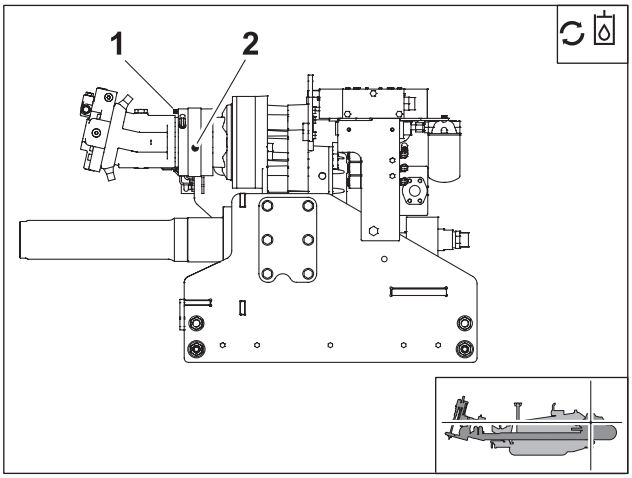
Change Spindle Brake Oil



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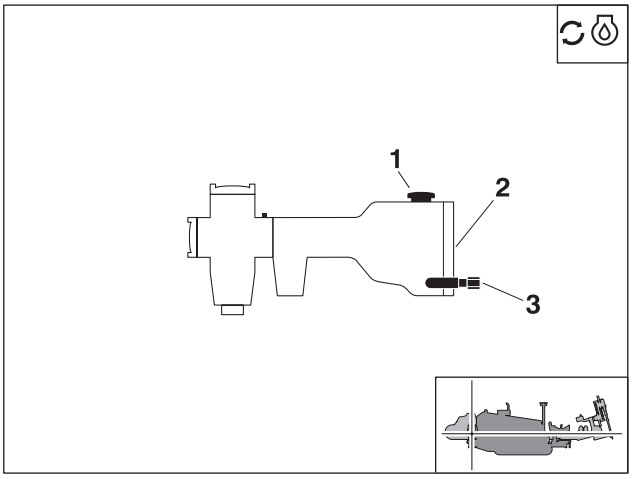
Change oil every 1000 hours. Capacity is 5 oz (148 mL) of THF.

To change:

1. Remove outer rotation motor. See Repair Guide.
2. Loosen six bolts (1) holding spindle brake together.
3. Pull spindle brake apart until oil comes out.
4. After all oil is drained, tighten bolts to rejoin brake.
5. Refill with 5 oz (148 mL) of THF at fill plug (2). Do not overfill.
6. Reinstall outer rotation motor. See Repair Guide.

Change Fluid Pump Oil



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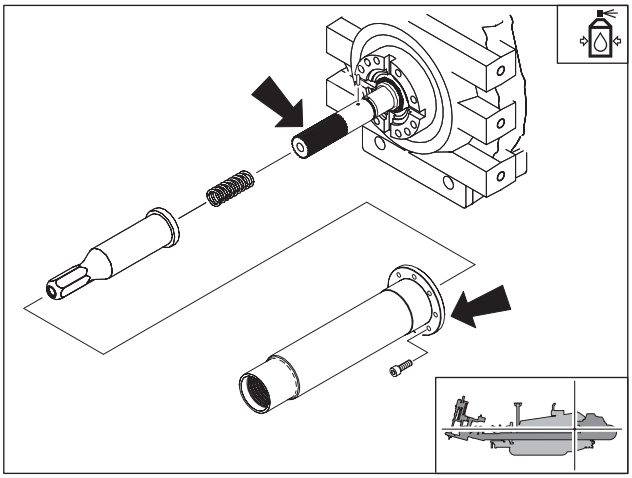
Change oil after first 50 hours and every 1000 hours thereafter. Maintain fluid level at halfway point on sight glass or at petcock level (2). Drain at plug (3). Fill at cap (1) with SAE 30 non-detergent engine oil. Capacity for 70 gpm pump is 4 qt (3.8 L). Capacity for 120 gpm pump is 10 qt (9.4 L).

Lube Saver Sub Wrench Collar and Sliding Output Shaft

Lube with EPL spray every 50 hours.



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Check Engine Drive Belt

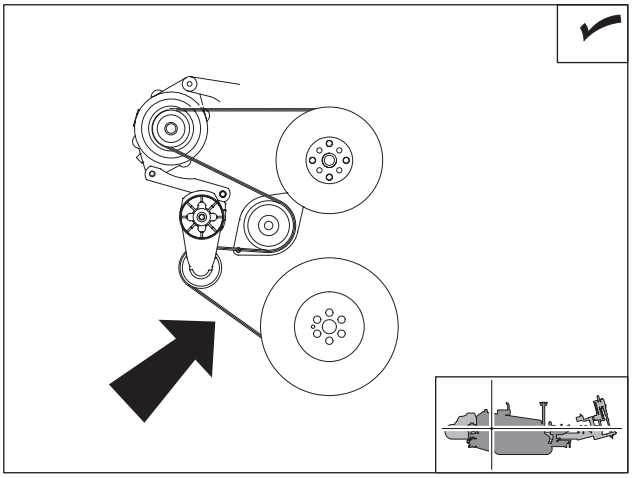
Check engine drive belt every 1000 hours. Check for cracked, stretched, or loose belt. Replace belt as needed. Belt tensioner cannot be adjusted or repaired. Replace if faulty.

To check belt tension:

- Visually check gap between stops.
- Replace belt before stops touch.

IMPORTANT:

- As belt stretches, stops will move closer together.
- See engine manual for information on checking automatic tensioner and changing belts.



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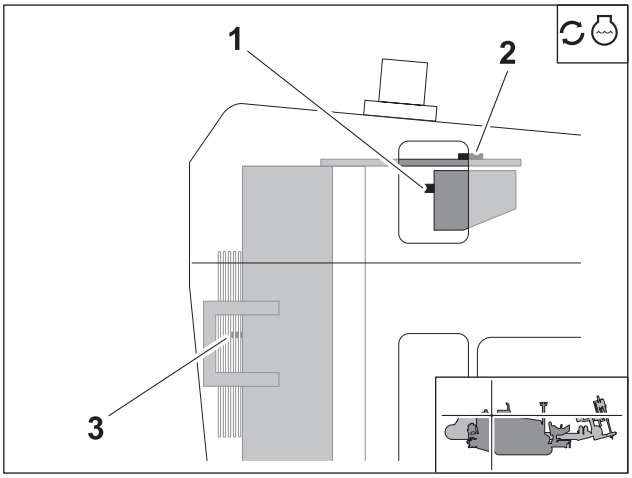
2000 Hour

Location	Task	Notes
DRILLING UNIT	Change engine coolant	

Drilling Unit

Change Engine Coolant



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Drain cooling system at drain every two years or 2000 hours. Drain cooling system at drain (3) and refill at radiator cap (2) with approved coolant. Capacity is 7.7 gal (29 L). Check level at sight glass (1).

NOTICE:

- Coolant change interval depends on coolant used and whether SCA levels are properly maintained. Read note above carefully to ensure coolant is changed at the correct interval.
- The use of non-approved coolant may lead to engine damage or premature engine failure and will void engine warranty.
- Use only distilled water for mixing coolants. Do not use tap water.
- See "Recommended Lubricants/ Service Key" on page 178 for list of approved coolants.

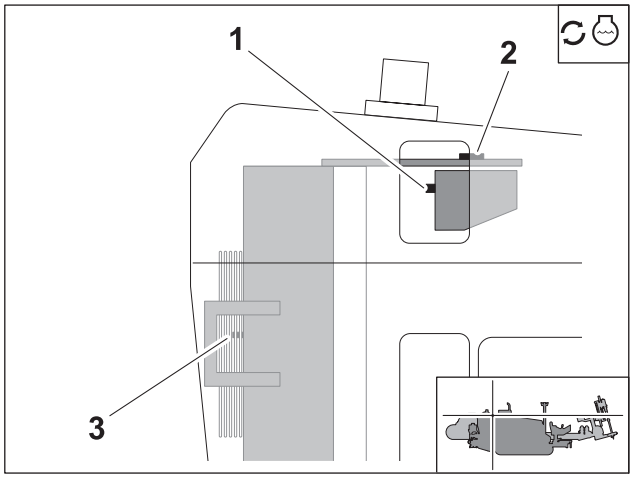
5000 Hour

Location	Task	Notes
DRILLING UNIT	Change engine coolant	

Drilling Unit

Change Engine Coolant

Drain cooling system at drain every two years or 2000 hours. Drain cooling system at drain (3) and refill at radiator cap (2) with approved coolant. Capacity is 7.7 gal (29 L). Check level at sight glass (1).



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NOTICE:

- Coolant change interval depends on coolant used and whether SCA levels are properly maintained. Read note above carefully to ensure coolant is changed at the correct interval.
- The use of non-approved coolant may lead to engine damage or premature engine failure and will void engine warranty.
- Use only distilled water for mixing coolants. Do not use tap water.
- See "Recommended Lubricants/ Service Key" on page 178 for list of approved coolants.

As Needed

Location	Task	Notes
DRILLING UNIT	Change air filter	
	Change auto lubricator TJC pail	TJC
	Change hydraulic filters	any time system is opened
	Check pipeloader inserts	
	Check and adjust carriage rollers	
	Check anchor driver glide strips	
	Check front pipe glide blocks	
	Check pipe lubricator insert	
	Check fluid pump ball valve	
	Check track tension and condition	
	Check track support slide pads	
	Check saver sub	
	Replace fuses	
	Change inner water swivel (seal kit)	

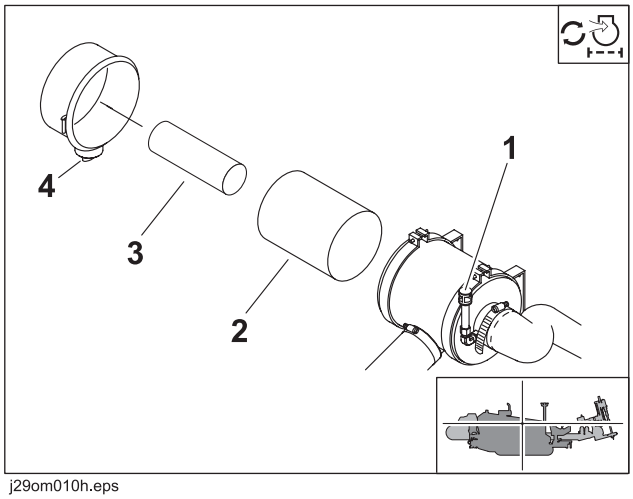
Drilling Unit

Change Air Filter

Change air filter when red band on air filter service indicator (1) pops up.

To change:

1. Loosen clamp ring and remove end cup (4).
2. Remove elements (2, 3).
3. Wipe inside of housing and wash end cup.
4. Install new elements.
5. Install end cup and tighten clamp ring.
6. Reset air filter service indicator.



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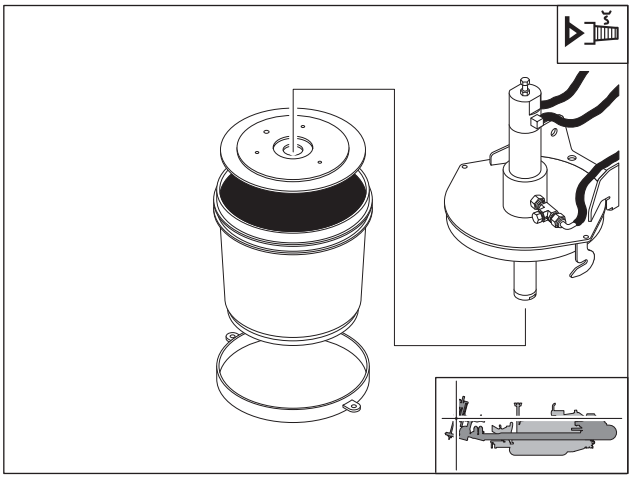
Change Auto Lubricator TJC Pail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Check pipe auto lubricator TJC level and change pail as needed.

To change pail:

1. Remove wingnuts and bolts attaching base ring (4) to pail cover (1).
2. Rotate base ring slightly to clear hooks on cover and remove pail from cover.
3. Remove follower plate (3) from empty pail and install into new pail. Press firmly on follower plate until TJC comes up in center opening.
4. Remove base ring from empty pail and install onto new pail.
5. Install pail into place over pump dip tube. Use hooks on cover to support base ring.
6. Install bolts and wingnuts.
7. Remove cap (2) from discharge tee on pump. Operate pump until discharged TJC is free of air pockets. Replace cap.

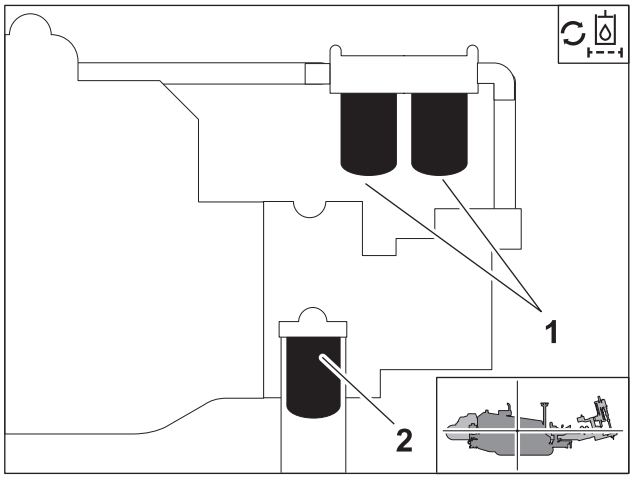
NOTICE: Use only genuine Ditch Witch tool joint compound to maintain warranty. See "Recommended Lubricants/Service Key" on page 178 for more information.

Change Hydraulic Filters (Anytime System Opened)

Change three hydraulic filters anytime system is opened for repair. Change filters (1, 2). Check fluid level, and add THF at hydraulic oil fill, if necessary.

IMPORTANT:

- If ambient temperature exceeds 100°F (37°C) for 50% of time, change oil and filter every 500 hours.
- If hydraulic system must be opened for repair, install new filter (p/n 157-486) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with clean filter. After 50 hours of normal operation, replace with clean filter.
- For major repairs with likely system contamination, change hydraulic fluid also.



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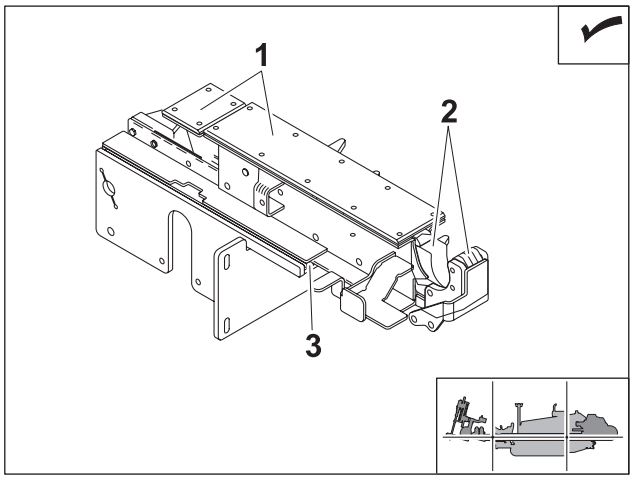
Check Pipeloader Inserts

Check pipeloader inserts at indicated areas for wear. Flip gripper inserts for longer wear, or replace as needed. See your Ditch Witch dealer for replacement parts.

1. Shuttle wear pads
2. Pipe gripper inserts
3. Slide pads

IMPORTANT: Ensure bolts are tightened evenly to enable inserts to slide freely and wear evenly.



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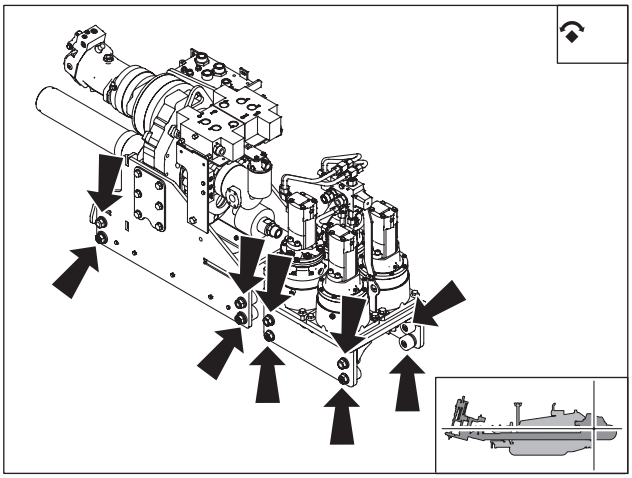
Check and Adjust Carriage Rollers

Check and adjust carriage rollers, replace as needed.



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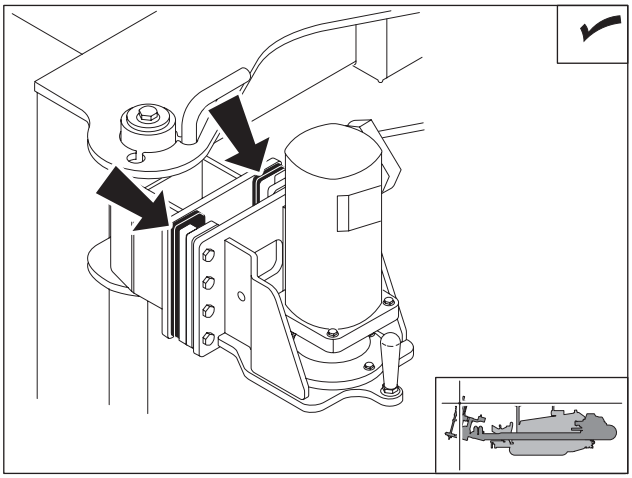
Check Anchor Driver Glide Strips

Check anchor driver glide strips for wear. Tighten or replace as needed. See your Ditch Witch dealer for replacement parts.



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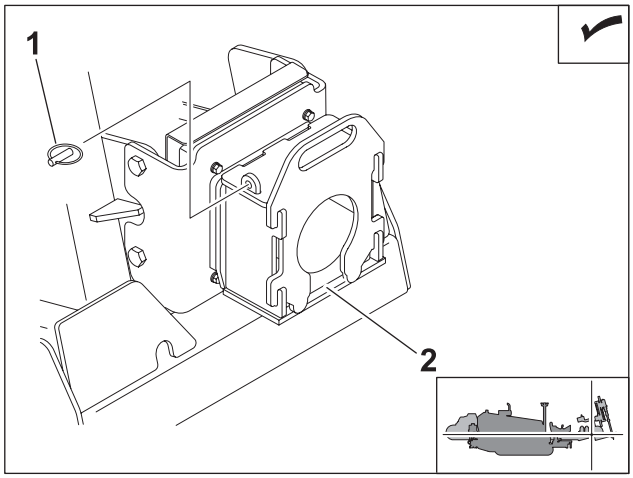
Check Front Pipe Guide Blocks

Check front pipe guide blocks for wear. Rotate blocks for longer wear, or replace as needed. See your Ditch Witch dealer for replacement parts.

To replace:

1. Remove lynch pins (1, one on each side).
2. Remove guide blocks (2).
3. Replace in reverse order.



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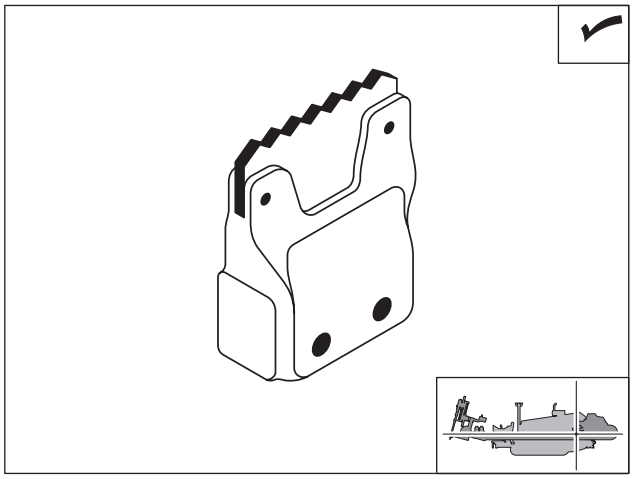
Check Pipe Lubricator Insert

Check pipe lubricator insert for wear, replace as needed. See your Ditch Witch dealer for replacement parts.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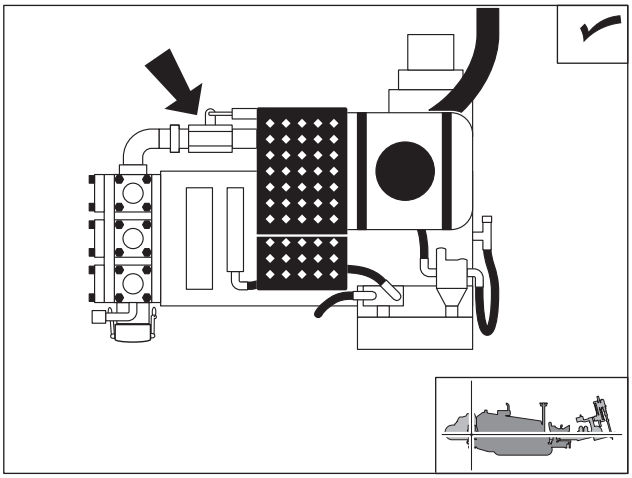
Check Fluid Pump Ball Valve

Check hydraulic ball valve for leaks. Tighten stem packing as needed. See your Ditch Witch dealer for replacement packing.



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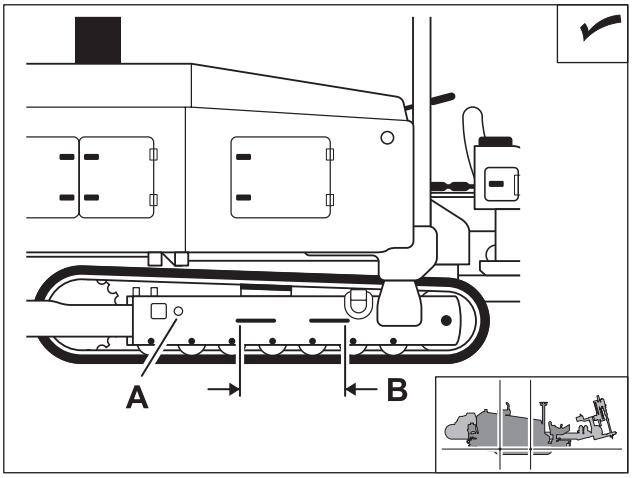
Check Track Tension and Condition

Check track tension and condition, and adjust or replace as needed. See your Ditch Witch dealer for replacement parts.

To adjust:

1. Pump MPG into fitting (A) until spring height is 17 3/4-18" (451-457 mm) when measured through windows (B).
2. Drive straight forward one machine length and check tension again.



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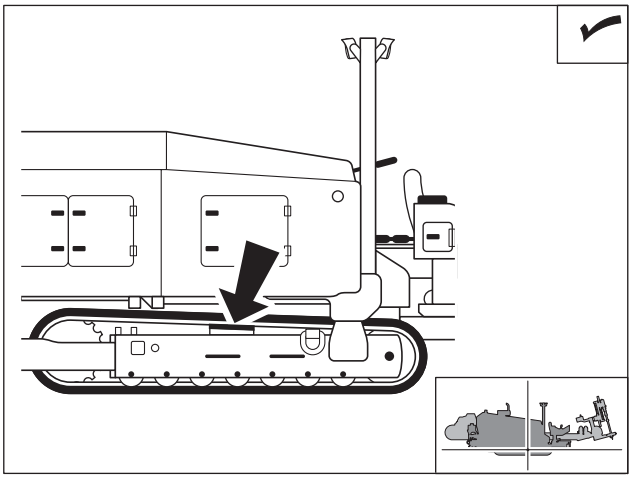
Check Track Support Slide Pads

Check track support slide pads. Replace as needed. See your Ditch Witch dealer for replacement parts.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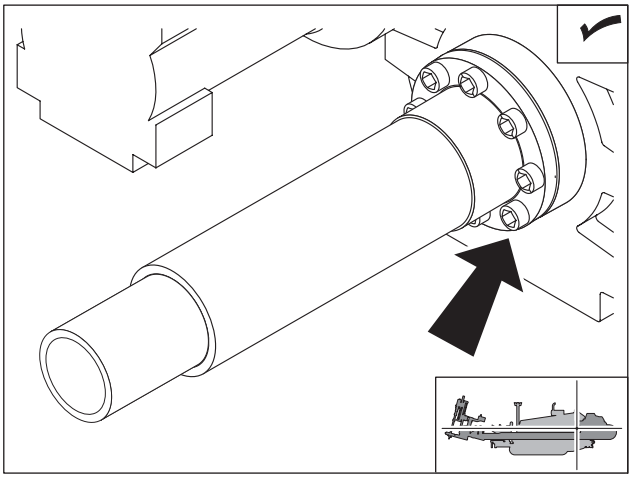
Check Saver Sub

Check saver sub and replace as needed. See your Ditch Witch dealer for replacement parts.

To replace:

1. Remove eight bolts (shown) that attach saver sub to spindle. Do not remove indexing dowels from spindle.
2. Remove and replace o-ring, if necessary.
3. Install in reverse order and torque eight bolts in a cross pattern to 225 ft•lb (305 N•m).
   Apply Loctite® 242 to bolts before installation.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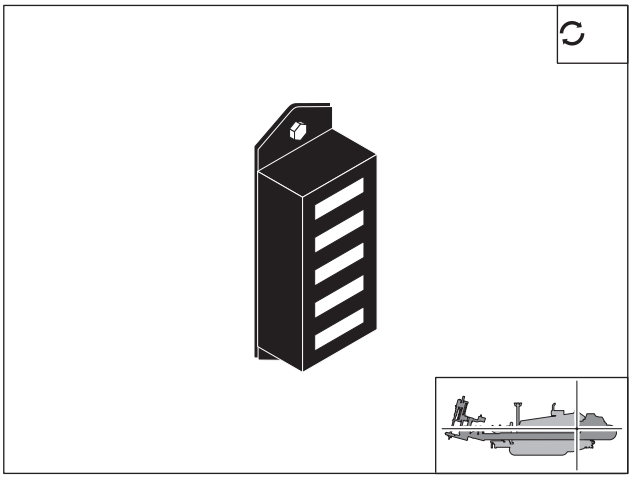
Replace Fuses

Change fuses as needed. One group of fuses is located behind a bolt-on panel between the ROPS. Refer to decal inside panel to identify fuses. The other group of fuses is located inside a door on the side of the left control console. Refer to decal inside door to identify fuses.



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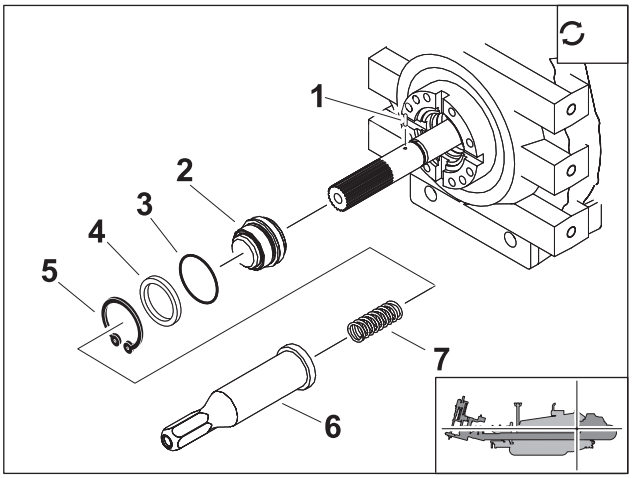
Change Inner Water Swivel (Seal Kit)

Replace inner water swivel (seal kit) as needed. See your Ditch Witch dealer for replacement parts.

To replace:

1. Remove saver sub. Do not remove indexing dowels from spindle.
2. Remove hex (6) and spring (7) from drive shaft.
3. Remove snap ring (5).
4. Remove seal (4) and main body (2).



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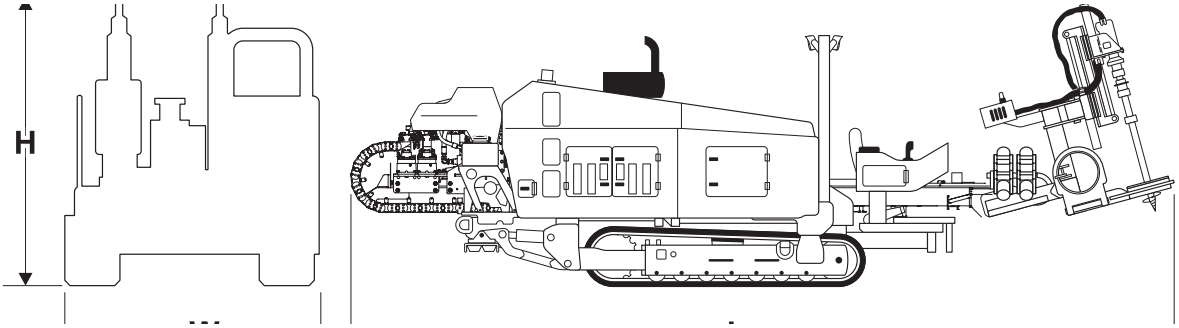
IMPORTANT: Use care when handling main body to avoid seal contamination. Do not allow grease to touch inner seals during installation.

5. Inspect dowel pin (1). To replace, drive new pin into different hole until top of pin is flush with shaft larger diameter.
6. Slide new main body (1) onto drive shaft. Check o-ring (3) and replace if needed.
7. Lightly coat seal (3) with SAE 30 engine oil and install onto main body.

NOTICE: Do not run seals without lubrication. Damage will occur.

8. Slide snap ring (4) onto main body.
9. Compress seal kit until snap ring is properly seated.
10. Install hex (5) and spring (6).
11. Install saver sub. See page 211.

Specifications



Dimensions		U.S.	Metric
L, length (per SAE J2022)		337in	8.6 m
W, width (per SAE J2022)		87 in	2.2 m
H, height over exhaust stack (per SAE J2022)		96 in	2.4 m
Angle of approach		17°	17°
Angle of departure		13°	13°
Weight (per SAE J2022)			
	JT mode	27,670 lb	12,550 kg
	AT mode	28,170 lb	12,778 kg

All Terrain Pipe		U.S.	Metric
Length, without inner pipe (per SAE J2022)		171 in	4.3 m
Joint diameter (per SAE J2022)		4.13 in	105 mm
Tubing diameter (per SAE J2022)		3.63 in	92 mm
Minimum bend radius		300 ft	91.4 m
Weight, with inner pipe (per SAE J2022)		264 lb	120 kg
Pipe box weight			
	large AT pipe box with 18 pipe	5580 lb	2531 kg
	small AT pipe box with 9 pipe	3150 lb	1429 kg

Mach 1 Power Pipe		**U.S.**	**Metric**
Length (per SAE J2022)		177 in	4.5 m
Joint diameter (per SAE J2022)		3.5 in	89 mm
Tubing diameter(per SAE J2022)		2.81 in	71 mm
Minimum bend radius		190 ft	58 m
Weight (per SAE J2022)		158 lb	71 kg
Pipe box weight			
	large JT pipe box with 32 pipe	6000 lb	2721 kg
	small JT pipe box with 16 pipe	3100 lb	1406 kg

Operational		**U.S.**	**Metric**
Spindle speed (per SAE J2022)			
	inner pipe	0-250 rpm	0-250 rpm
	outer pipe	0-240 rpm	0-240 rpm
Spindle torque (per SAE J2022)			
	inner pipe, max	2000 ft•lb	2712 N•m
	outer pipe, max	5000 ft•lb	6780 N•m
Carriage speed (per SAE J2022)		0-120 fpm	0-37 m/min
Pullback force (per SAE J2022)		40,000 lb	178 kN
Thrust force (per SAE J2022)			
	actual, All Terrain mode	25,000 lb	111 kN
	actual, JT and AT dirt modes	36,000 lb	160 kN
Minimum bore diameter			
	All Terrain with roller cone bit	6.25 in	159 mm
	JT with soil bit	5 in	127 mm
Backream diameter		variable	variable
Ground drive speed (per SAE J2022)			
	forward	0-2.5 mph	0-4 km/h
	reverse	0-2.5 mph	0-4 km/h

Power		U.S.	Metric
Engine: Cummins QSB 6.7			
Fuel: diesel			
Cooling medium: ASTM D5345			
Cylinders: 6			
Displacement		409 in^3	6.7 L
Bore		4.21 in	107 mm
Stroke		4.88 in	124 mm
Power			
	manufactuer's gross power rating (per SAE J1995)	190 hp	142 kW
	rated speed	2400 rpm	2400 rpm
	estimated net power (per SAE 1349)	175 hp	131 kW

Drilling Fluid System		U.S.	Metric
Maximum drilling fluid flow (per SAE J2022)			
	JT mode	120 gpm	454 L/min
	AT mode	70 gpm	265 L/min
Maximum drilling fluid pressure (per SAE J2022)		1300 psi	90 bar

Fluid Capacities	U.S.	Metric
Fuel tank *	55 gal	208 L
Hydraulic reservoir	36 gal	136 L
Engine oil, including filter	20 qt	19 L
Engine cooling system	31 qt	29 L
Antifreeze tank	8 gal	30 L

* Under normal operating conditions, a full tank of fuel will last 10-14 hours.

Battery
SAE reserve capacity 195 min, 12V, negative ground, SAE cold crank @ 0°F (-18°C), 2 batteries @ 950A each.

Noise Levels
Exterior 109 dBA sound power per ISO 6395 Operator 90 dBA sound pressure per ISO 6394

Specifications are called out according to SAE recommended practices. Specifications are general and subject to change without notice. If exact measurements are required, equipment should be weighed and measured. Due to selected options, delivered equipment may not necessarily match that shown.

Support

Procedure

Notify your dealer immediately of any malfunction or failure of Ditch Witch equipment.

Always give model, serial number, and approximate date of your equipment purchase. This information should be recorded and placed on file by the owner at the time of purchase.

Return damaged parts to dealer for inspection and warranty consideration if in warranty time frame.

Order genuine Ditch Witch replacement or repair parts from your authorized Ditch Witch dealer. Use of another manufacturer's parts may void warranty consideration.

Resources

Publications

Contact your Ditch Witch dealer for publications and videos covering safety, operation, service, and repair of your equipment.

Ditch Witch Training

For information about on-site, individualized training, contact your Ditch Witch dealer.

Warranty

Ditch Witch Equipment and Parts Limited Warranty Policy

Subject to the limitations and exclusions herein, free replacement parts will be provided at any authorized Ditch Witch dealership for any Ditch Witch equipment or parts manufactured by The Charles Machine Works, Inc. (CMW) that fail due to a defect in material or workmanship within one (1) year of first commercial use (Exception: 2 years for all SK attachments). Free labor will be provided at any authorized Ditch Witch dealership for installation of parts under this warranty during the first year following initial commercial use of the serial-numbered Ditch Witch equipment on which it is installed.

Exclusions from Product Warranty

- Wear-related failure of parts subject to ground contact including, but not limited to, digging teeth, digging chains, sprockets, backhoe buckets, plow blades, drill pipe, drill bits, backreamers, and swivels.
- All incidental or consequential damages.
- All defects, damages, or injuries caused by misuse, abuse, improper installation, alteration, neglect, or uses other than those for which products were intended.
- All defects, damages, or injuries caused by improper training, operation, or servicing of products in a manner inconsistent with manufacturer's recommendations.
- All engines and engine accessories (these are covered by original manufacturer's warranty).
- Tires, belts, and other parts which may be subject to another manufacturer's warranty (such warranty will be available to purchaser).
- All implied warranties not expressly stated herein, including any warranty of fitness for a particular purpose and merchantability.

IF THE PRODUCTS ARE PURCHASED FOR COMMERCIAL PURPOSES AS DEFINED BY THE UNIFORM COMMERCIAL CODE, THEN THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE FACE HEREOF AND THERE ARE NO IMPLIED WARRANTIES OF ANY KIND WHICH EXTEND TO A COMMERCIAL BUYER. ALL OTHER PROVISIONS OF THIS LIMITED WARRANTY APPLY INCLUDING THE DUTIES IMPOSED.

Ditch Witch products have been tested to deliver acceptable performance in most conditions. This does not imply they will deliver acceptable performance in all conditions. Therefore, to assure suitability, products should be operated under anticipated working conditions prior to purchase.

Defects will be determined by an inspection within thirty (30) days of the date of failure of the product or part by CMW or its authorized dealer. CMW will provide the location of its inspection facilities or its nearest authorized dealer upon inquiry. CMW reserves the right to supply remanufactured replacements parts under this warranty as it deems appropriate.

Extended warranties are available upon request from your local Ditch Witch dealer or CMW.

Some states do not allow exclusion or limitation of incidental or consequential damages, so above limitation of exclusion may not apply. Further, some states do not allow exclusion of or limitation of how long an implied warranty lasts, so the above limitation may not apply. This limited warranty gives product owner specific legal rights and the product owner may also have other rights which vary from state to state.

For information regarding this limited warranty, contact CMW's Product Support department, P.O. Box 66, Perry, OK 73077-0066, or contact your local Ditch Witch dealer.

First version: 1/91; Latest version: 1/03

A Note To Ditch Witch Equipment Owners:

If your equipment was purchased through a Ditch Witch dealer, there is no need to read further.

However, if you purchased from any other source, please fill out the form on the reverse side and return it to us.

This will enable you to receive updates on this equipment as well as information on new products of interest.

Thanks for using Ditch Witch equipment.

(Please Fold Along This Line And Seal At Bottom With Tape)

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO 23 PERRY OKLAHOMA

POSTAGE WILL BE PAID BY

The Charles Machine Works, Inc.
P.O. Box 66
Perry, Oklahoma 73077-9989

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P.O. Box 66
Perry, Oklahoma 73077-9989

Ditch Witch® Registration Card

Please Type or Print All Information

Purchaser's Company Name

Attention

Street Address or P.O. Box

City County

State Zip Nation

( )

Phone Number With Area Code

Model Serial Number

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Name of Ditch Witch Dealership

Your Signature

Ditch Witch® Registration Card

Please Type or Print All Information

Purchaser's Company Name

Attention

Street Address or P.O. Box

City County

State Zip Nation

( )

Phone Number With Area Code

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Attachments/Accessories Serial Numbers

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Name of Ditch Witch Dealership

Your Signature

Service Record

Service Performed	Date	Hours

Service Performed	Date	Hours